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J B F Scientific Corp, Burlington, Mass

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A sensitivity analysis of a computer simulation model is described in the report for evaluating phosphorus removal strategies. Eighteen input parameters have been analyzed for five different communities and their respective sewage treatment plants. The results are useful for determining where the greatest effort in data collection should be expended to provide realistic input data for this model.

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SENSITIVITY ANALYSIS OF A PHOSPHORUS REMOVAL STRATEGY COMPUTER MODEL

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ABSTRACT

A sensitivity analysis of a computer simulation model for evaluating phosphorus removal strategies has been conducted. Eighteen input parameters have been analyzed for five different communities and their respective sewage treatment plants. The results are useful for determining where the greatest effort in data collection should be expended to provide realistic input data for this model.

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SECTION I

CONCLUSIONS

1. The results of the sensitivity analysis of the phosphorus removal strategy model REMOVE indicate which input variables (or parameters) have the greatest effect on the various treatment costs which are the output of REMOVE.

2. The parameter with the greatest effect is ELIMIT, the effluent level in mg/l of phosphorus. Costs were observed to increase as much as 200% when ELIMIT changed from 2 mg/l to 0. 1 mg/l. It is difficult to compare these costs, however, because the treatment schemes used to reach each effluent level of 2., 0. 5, 0. 3, and 0. 1 were different. The results do show that as a zero discharge condition is approached, the costs increase significantly.

3. The parameter with the second greatest effect is PINPS, the influent (raw wastewater) total phosphorus level in mg/l. Varying the value of PINPS from 25% to 200% of its base value for the least costly treatment scheme resulted in a variation of 41% to 179% of the base unit cost value. The basic reasons for significant influence of PINPS on the total phosphorus removal cost are as follows. First, all the removal schemes are chemical precipitation methods. Secondly, chemical usage (and therefore chemical cost) is directly related to PINPS by the fixed weight ratio of the precipitant cation to phosphorus. Thirdly, the amount of sludge (and therefore sludge handling equipment) is directly related to the amount of chemical usage.

4. The parameter with the third greatest effect is ALUMCS, the cost of alum in $/lb, (for those treatment schemes which use alum). This results from the large fraction of the total cost attributable to chemical costs. For one particular case, varying ALUMCS from 25% to 200% of its base value caused total unit costs to vary from 47% to 171% of its base value.

5. We can also conclude that the FECLCS, the cost of ferric chloride in $/lb, (for those schemes using ferric chloride as a phosphorus removal agent) would have the same effect as ALUMCS. However, FECLCS was not specifically examined.

6. Another parameter of importance is MATRLS, the Wholesale Price Index (also known as inflation). In one case, a variation in MATRLS from 25% to 200% of its base value caused a variation in total costs from 58% to 156%. This again is because chemical costs are such a large fraction of the total cost.

7. The other parameters taken individually caused much smaller variations in total cost. However, most of the 18 parameters examined in the 5 case examples showed that while relatively little sensitivity was exhibited when taken individually, an analysis of composite effects might indicate some major effects. For example, an upward shift in materials costs together with a higher influent phosphorus level and a lower required effluent level would certainly have severe cost implications.

SECTION II

RECOMMENDATIONS

1. It is extremely important that those input parameters to the model which have significant effects on the cost of phosphorus removal have well defined values for the specific cases being examined. This requires that either the model be maintained in a broadly applicable status by EPA or that the user be aware of the necessity for accurate input data defining his specific case.

2. The model REMOVE should be developed and refined further. One parameter in particular needs to have its role explicitly expanded. This parameter is ELECOS, the cost of electricity in $/KWHR. Most of the cost curves developed by Black and Veatch in Reference 1 include the cost of electricity by assuming an average power cost of 1¢/KWHR. For many parts of the U.S. the cost of power for industrial users is approaching 2¢/KWHR. At the present time the model does not provide for this cost escalation except as it may be covered in the Wholesale Price Index multiplier. The sensitivity analyses for influence of power cost are at the present time insensitive to changes in this parameter value.

3. The basic cost data for waste treatment processes needs to be continually updated by EPA. Models such as REMOVE are dependent upon accurate, statistically significant data. The basic data, upon which many cost estimates are presently being made, is several years old. It is not sufficient to assume that this data can continue to be reliably updated by applying various escalation factors such as the Waste Treatment Construction Cost Index and the Wholesale Price Index.

SECTION III

INTRODUCTION

In recent years, eutrophication of lakes and slow moving rivers has received great attention. A tentative conclusion of this research is that phosphorus is a limiting nutrient in most cases of extended eutrophication. For this reason, and because phosphorus can be easily removed from waste streams, the sewage treatment plant has been chosen as the place to remove some of the phosphorus entering water bodies. However, in order to determine the feasibility of phosphorus removal from a cost viewpoint, the cost of various treatment alternatives for a particular community have to be determined. A computer simulation model for this purpose was developed under EPA Contract No. 68-01-0758. The model which is named REMOVE calculates the costs of a number of removal schemes which are physically capable of achieving a desired phosphorus effluent level. The input to the model includes a description of the community, its sewage treatment plant, and the characteristics of the sewage. Additional input data includes the desired time horizon, desired effluent phosphorus level, detergent restrictions, and state and federal government financial help.

For any given case study (i.e., community and treatment plant), there are upwards of fifty input parameters (or variables). It is very difficult to obtain accurate information concerning all of these. It therefore becomes necessary to determine which ones are important from the model's point of view. This is the purpose of sensitivity analysis. By knowing which parameters are significant, a user can then determine where to best direct his/her money and energy in the data collection effort.

The objective of this sensitivity analysis was to observe the changes in treatment costs which occurred as the values of the individual input parameters changed. For this effort, eighteen parameters were examined for each of five cases (treatment plants). These parameters and their description are given in Table 1.

The effects of all of the parameters except ELIMIT were examined in the same manner. The program REMOVE was modified so that as each parameter assumed 25%, 50%, 100%, 150%, and 200% of its base (or initial) value, the percentage change in unit costs for amortized construction; labor, materials and supplies; phosphate detergent restriction; solid sinks (i.e., sludge disposal); and total were printed out. These results are the heart of the sensitivity analysis. A set of graphs is provided for each separate case study. Only those percentages associated with the lowest cost treatment scheme in each case were computed and printed. The lowest cost scheme was determined by running REMOVE on each case prior to the sensitivity analysis.

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TABLE 1

PARAMETERS

ALUMCS - Cost of alum ($/lb.)

AMLIFE - Amortization lifetime of equipment which is built for phosphorus removal (years)

AMRATE - Amortization rate of capital cost of equipment which is built for phosphorus removal

CNSTRC - WQO-STP index

DHR - Average direct hourly labor rate for all treatment plant employees ($/hr)

DIFCOS - Differential cost between old (phosphate) detergent and new (less phosphate or none) detergent ($/lb detergent)

DTRGUS - Annual per capita detergent usage (lb/capita/year)

ELIMIT - The effluent limit which the treatment plant is trying to achieve (mg phosphorus/l)

ELECOS - Delivered cost of electricity ($/KWHR)

ENFCST - Annual per capita cost of enforcing low (or zero) phosphate detergent legislation ($/capita/yr)

GOVFF - Fraction of construction cost which will be financed by state and/or federal governments.

IDFRAC - Indirect labor costs (sick leave, vacations, other benefits) as a fraction of direct labor

LIMECS - Delivered cost of lime ($/lb CaO)

MATRLS - The Wholesale Price Index for Industrial Commodities

PCKLCS - Delivered cost of pickle liquor ($FeCl_2$) ($/lb $FeCl_2$)

PCNTNT - Legislated phosphorus content (proposed or current) of detergents

PINPS - Level of total phosphorus in raw wastewater (mg P/l)

TRNCST - Transportation cost of sludge disposal ($/ton-mile)

Table 2 contains the scheme numbers and a description of the scheme. For some parameters, the lowest cost scheme was not affected at all by the changes in the parameter value. An example of this is Case 1, the Marlboro plant where the lowest cost scheme was #10, ferric chloride added to the aeration basin. It is obvious that changing the price of alum would not affect this scheme and therefore for ALUMCS the lowest cost scheme using alum was chosen. This type of judgment was exercised whenever similar conflicts arose.

The effects of parameter ELIMIT, the phosphorus level in the plant effluent in mg/l, were examined in a slightly different manner. As ELIMIT assumes the values 2.0, 0.5, 0.3, and 0.1 mg P/l, different treatment schemes become the lowest cost schemes for accomplishing the desired effluent level. The graphs of the sensitivity of ELIMIT are, therefore, plotted as effluent level (and, therefore, treatment scheme) vs. unit cost for each of the six measures used for the other parameters.

The sensitivity analysis was performed for five different treatment plants. Four of these are actual plants in New England, while the fifth is a theoretically designed plant. It was felt that using actual treatment plant data would improve the realism and practicality of the results and conclusions. The first plant examined was the Westerly Treatment Plant in Marlboro, Mass. It is a 1.5 MGD activated sludge plant with a secondary settler. The sludge is dried by vacuum filtration and then trucked to a landfill site. The second plant was the MDC Treatment Plant in Clinton, Mass. This 2 MGD trickling filter plant anaerobically digests the sludges before sending it to sludge drying beds and then to a landfill site. Next in size, was a 5 MGD trickling filter plant with a gravity thickener and vacuum filtration for sludge handling. This plant was designed from theory using the model. Fourth, a 12 MGD activated sludge plant in Brockton, Mass. was examined. This plant uses air flotation and vacuum filtration for sludge handling. The last plant was the 50 MGD activated sludge plant in Providence, R.I., sludge is thickened by gravity, vacuum filtered and then incinerated before going to the landfill site. A complete description of each actual plant as determined from interviews with supervisory personnel can be found in the appendices of this report.

TABLE 2
TREATMENT SCHEMES

SCHEME #	SCHEME NAME	DESCRIPTION OF SCHEME
1	ALPYPS	Alum + polymer to primary settler
2	FCPYPS	Ferric chloride + polymer to primary settler
3	FCLMPS	Ferrous chloride + lime to primary settler
4	LIMEPS	Lime to primary settler
5	ALPYFB	Alum + polymer to flocculation basin
6	FCPYFB	Ferric chloride + polymer to flocc. basin
7	FCLMFB	Ferrous chloride + lime to flocc. basin
8	LIMEFB	Lime to the flocculation basin
9	ALUMAB	Alum to the aeration basin
10	FECLAB	Ferric chloride to aeration basin
11	NAALAB	Sodium aluminate to aeration basin
12	ALABMF	Alum to aer. basin + multi-media filtration
13	FCABMF	Ferric chloride to aer. basin + multi-media fil.
14	NAABMF	Sodium aluminate to aer. basin + multi-media fil.
15	ALUMTF	Alum after trickling filter
16	FECLTF	Ferric chloride after trickling filter
17	ALTFMF	Alum after trickling filter + multi-media filtr.
18	FCTFMF	Ferric chloride after trk. fil. + multi-media filtr.
19	ALFBAS	Alum to flocc. after conventional secondary
20	FCFBAS	$FeCl_3$ to flocc. after conventional secondary
21	L1FBAS	Lime (1-stage) to flocc. after conven. secondary
22	L2FBAS	Lime (2-stage) to flocc. after conven. secondary
23	NONE	No chemicals added for phosphorus removal

SECTION IV

CASE STUDIES

CASE 1 - MARLBORO, MASS.

Conclusions

The parameter with the greatest effect on the unit costs of treatment was ELIMIT, the phosphorus effluent level. As the effluent level was decreased from 2.0 mg P/l to 0.1 mg P/l, the cost of removal went from 7.6¢/kgal to 25.¢/kgal, an increase in cost of 200%. The next most important parameter was PINPS, the influent phosphorus level. As it was changed from 50% to 200% of its base value of 10. mg/l, the total cost of removal for the least costly scheme changed from 61% to 168% of its base value of 7.6¢/kgal. Changing ALUMCS, the cost of alum, from 25% to 200% of its base value of 3¢/lb caused the total treatment cost to go from 70% to 140% of its base value. MATRLS, the Wholesale Price Index, was next in influence causing costs to change from 79% to 128% as it went from 25% to 200% of its base value of May 72. Table 3 contains those parameters which caused one or more of the sub-measures to have a sensitivity $\geq |.4|$ ranked by the sensitivity of T, the total cost. Following this are the sensitivity graphs of all of the parameters.

Description

The Westerly Treatment Plant at Marlboro, Mass., is a 1.5 MGD activated sludge plant. The sludge is vacuum filtered before going to a landfill site 9 miles away. A complete listing of the input variables and values to the program SARMVE is contained in the appendices along with the plant survey results.

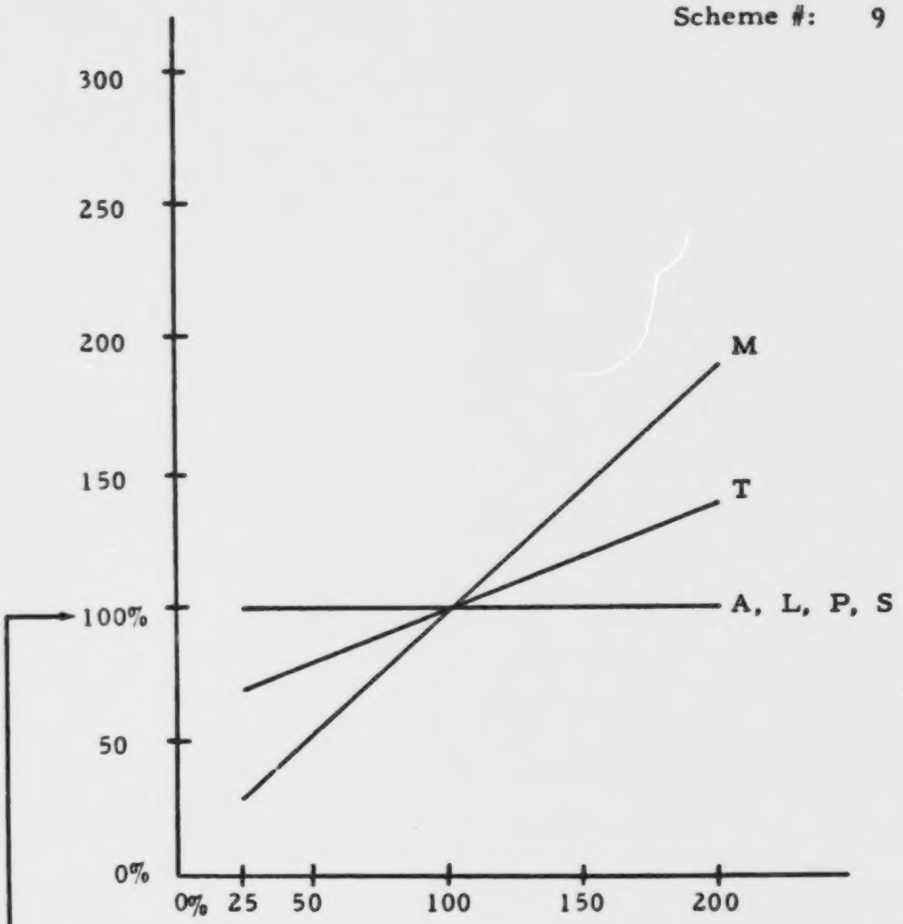
TABLE 3

Sensitivity Ranking - Case 1

	MEASURES					
PARAMETER	T	A	L	M	P	S
ELIMIT	*					
PINPS	.7		.5	1.4		1.4
ALUMCS	.4			.9		
MATRLS	.3			.1		
DHR	.2			1.		
PCNTNT	.2			.4		.4
TRNCST	.15					1.
AMLIFE	-.1	-.8				
CNSTRC	.1	1.				
DIFCOS	.1				.4	
ENFCST	.1				.6	
GOVFF	-.1	-1.				
LIMECS	.1			.7		
DTRGUS	-.07			-.4	.4	-.4
AMRATE	.05	.4				

*The sensitivity of ELIMIT is not computed on the basis of percent change.

Symbol: ALUMCS
Description: Alum Cost
Base Case: 1
Scheme #: 9

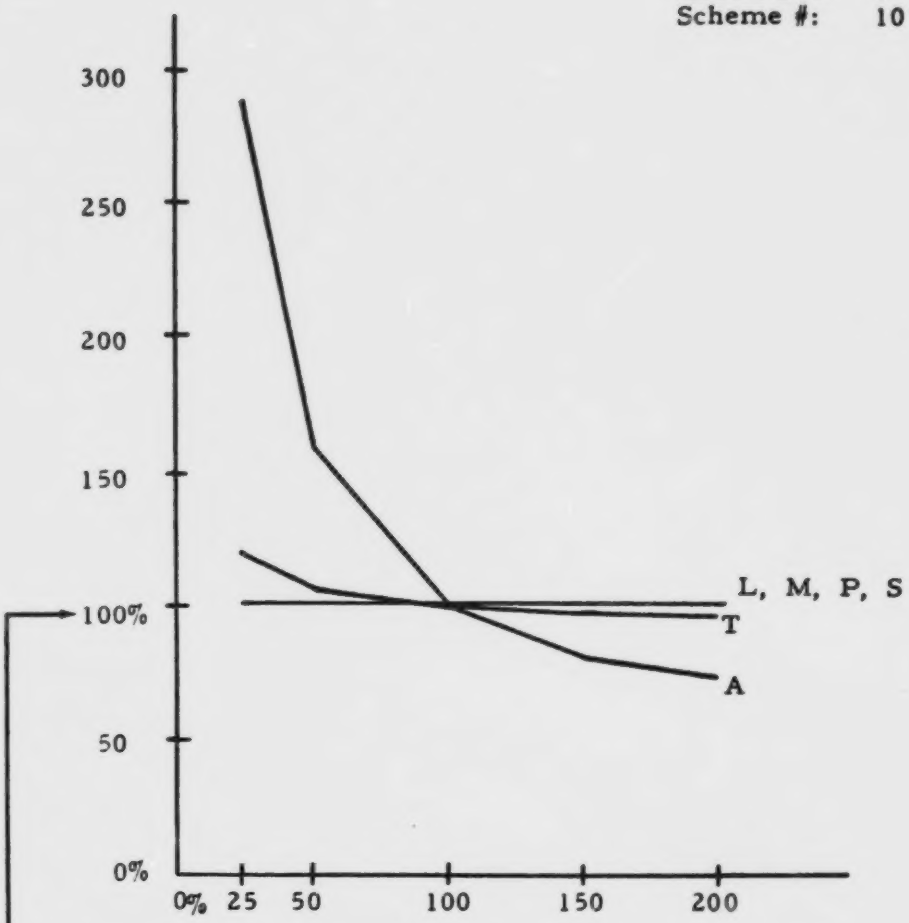


ALUMCS - .03$/lb = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.9 ¢/kgal = 100%
M = Unit Material & Supply Cost - 4.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 10.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.9	0	0	.4
Slope over the range	0	0	.9	0	0	.4

Symbol: AMLIFE
Description: Amortization Life
Base Case: 1
Scheme #: 10

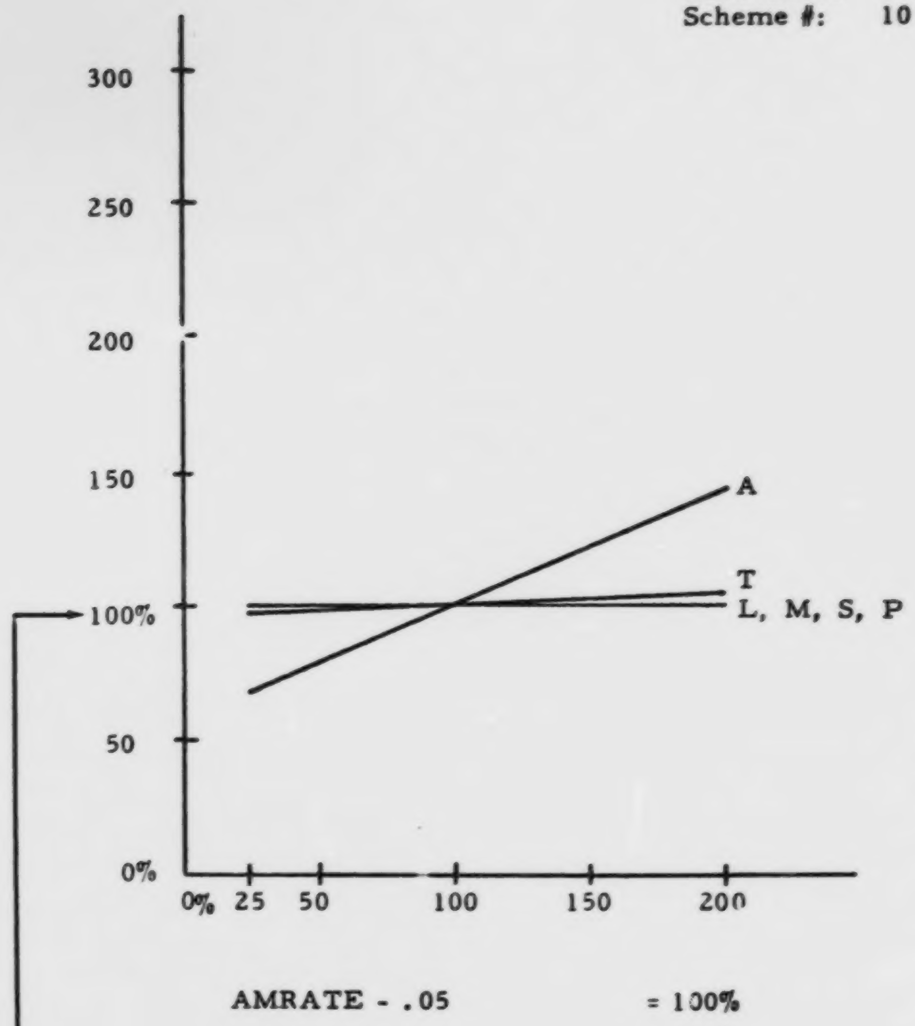


AMLIFE - 20 years = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-.8	0	0	0	0	-.05
Slope over the range	-1.2	0	0	0	0	-.1

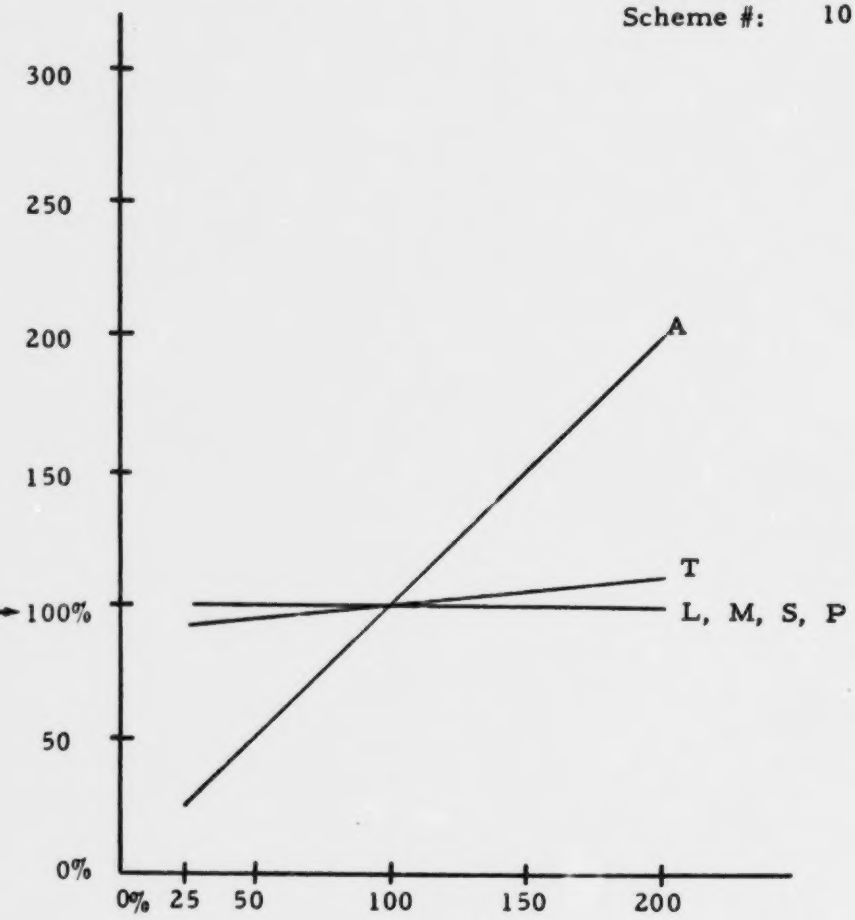
Symbol:	AMRATE
Description:	Amortization Rate
Base Case:	1
Scheme #:	10



A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.4	0	0	0	0	.05
Slope over the range	.4	0	0	0	0	.05

Symbol: CNSTRC
Description: WQO-STP Index
Base Case: 1
Scheme #: 10

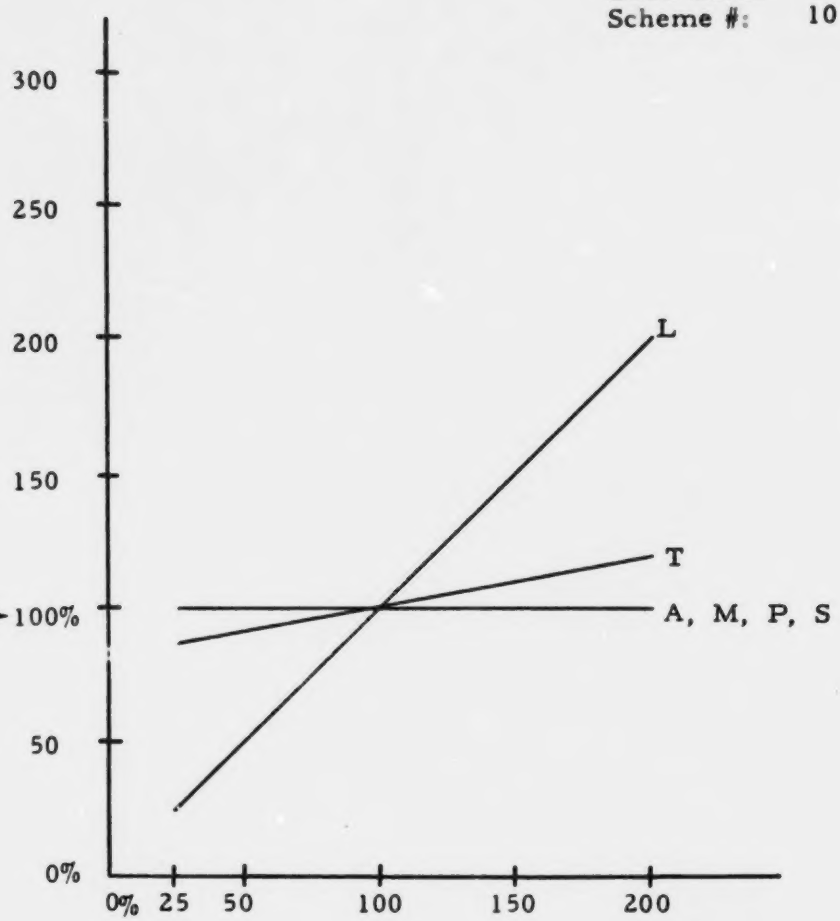


CNSTRC - 1.714 = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	1.	0	0	0	0	.1
Slope over the range	1.	0	0	0	0	.1

Symbol: DHR
Description: Labor Rate
Base Case: 1
Scheme #: 10

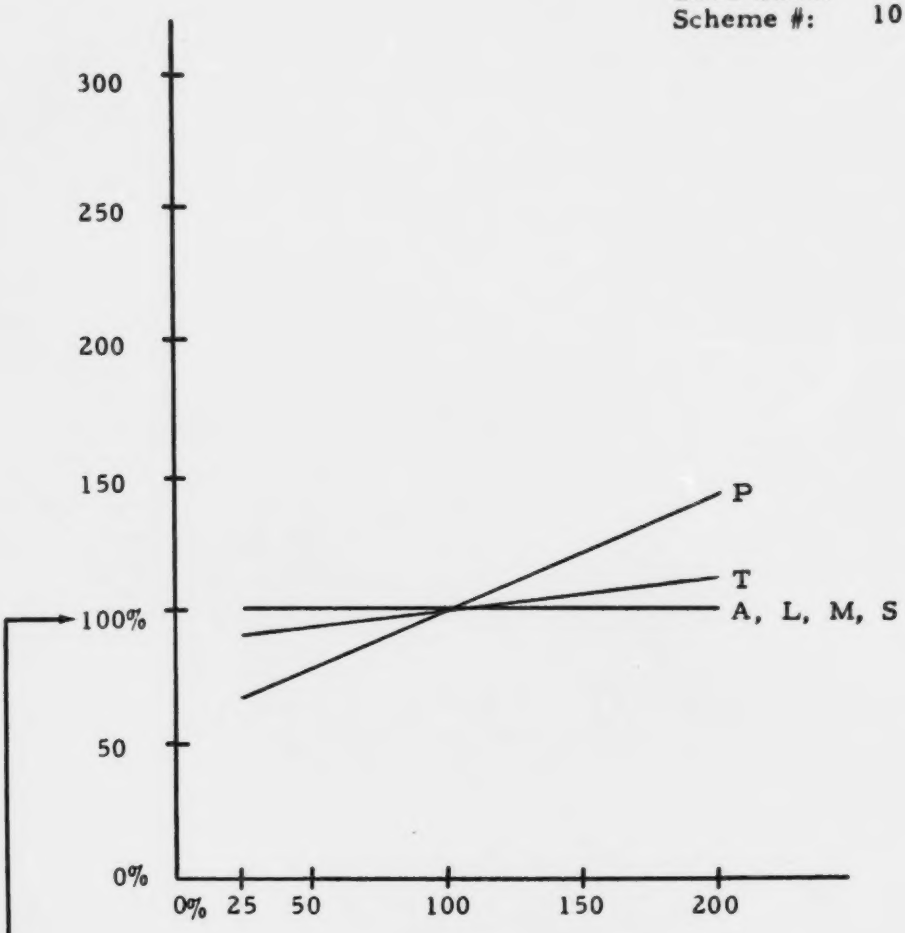


DHR - 4.10 $/hr = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	1.	0	0	0	.2
Slope over the range	0	1.	0	0	0	.2

Symbol: DIFCOS
Description: Cost of Detergent
Base Case: 1
Scheme #: 10

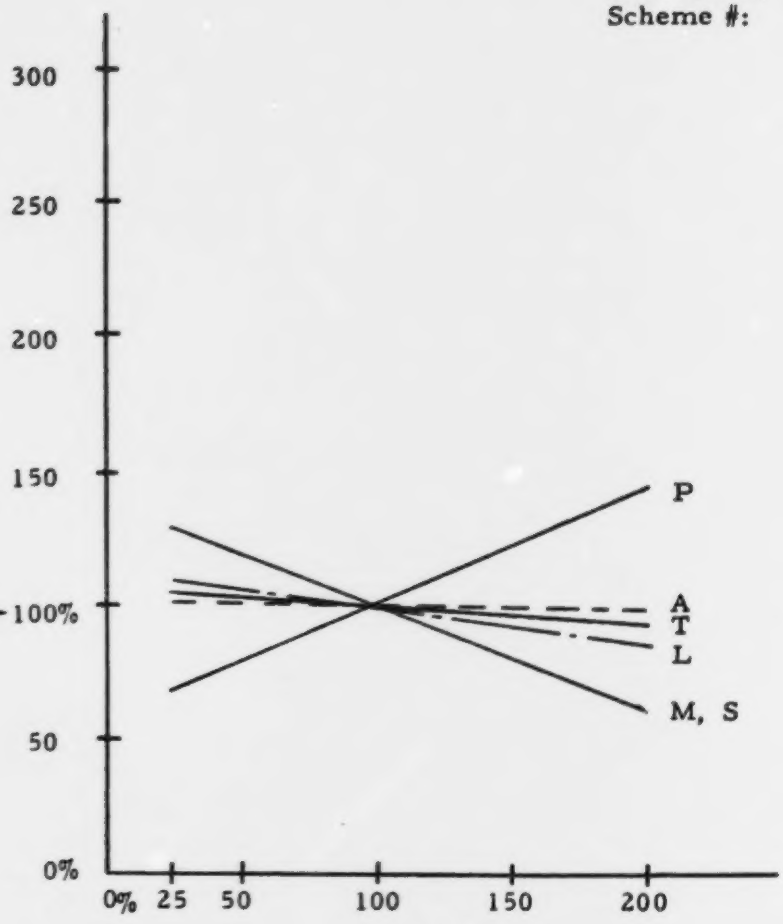


DIFCOS - .02 $/lb = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.4	0	.1
Slope over the range	0	0	0	.4	0	.1

Symbol: DTRGUS
Description: Detergent Use
Base Case: 1
Scheme #: 10

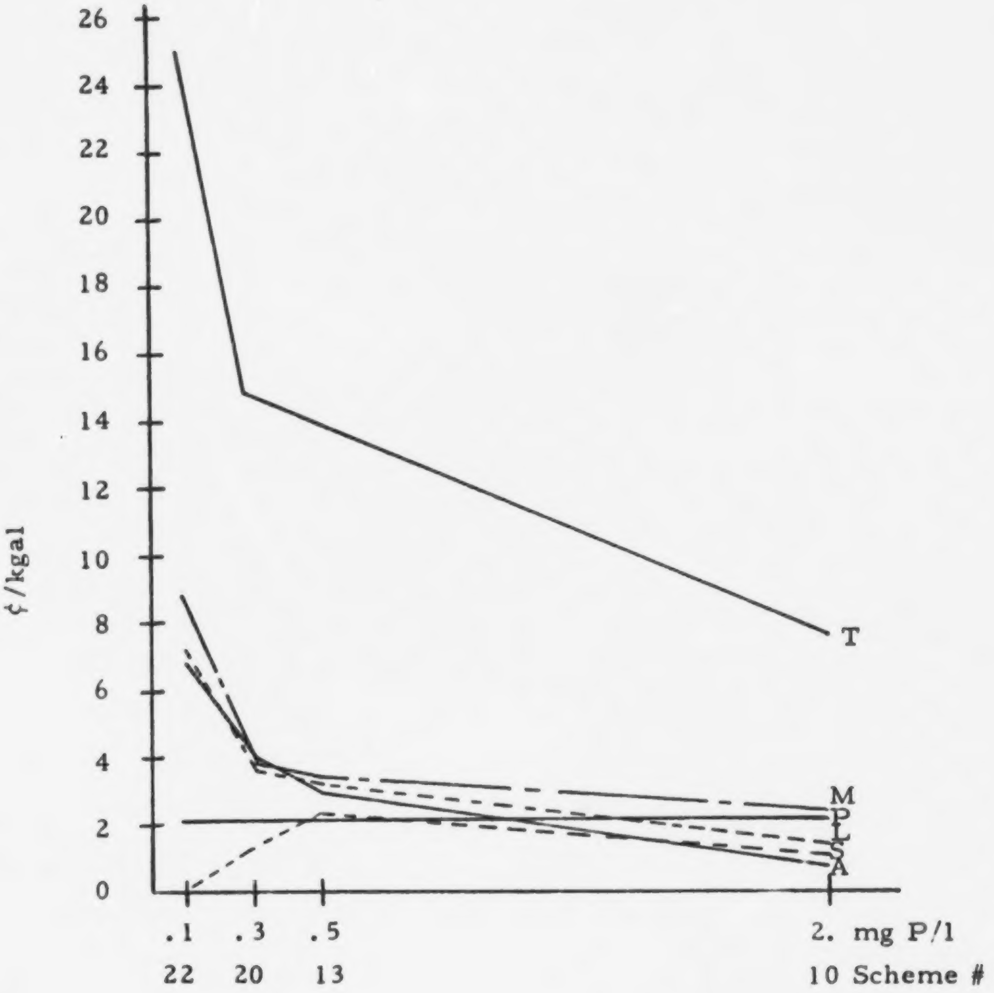


DTRGUS - 16 lb/cap/yr = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

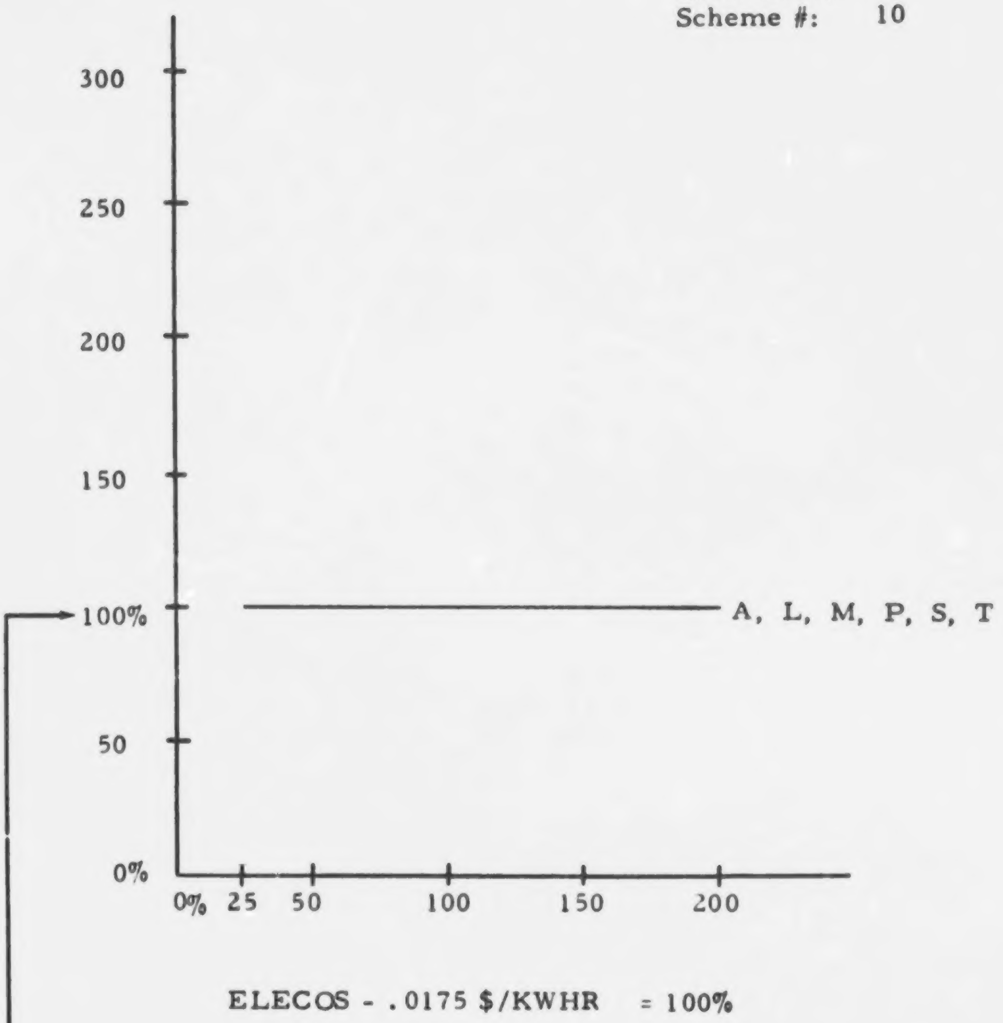
	A	L	M	P	S	T
Sensitivity at base point	-.02	-.1	-.4	+.4	-.4	-.07
Slope over the range	-.02	-.1	-.4	+.4	-.4	-.07

Symbol: ELIMIT
Description: Effluent Limit
Base Case: 1



A = Unit Amortization Cost
L = Unit Labor Cost
M = Unit Material & Supply Cost
P = Unit Detergent Limitation Cost
S = Unit Solid Sink Cost
T = Unit Total Cost

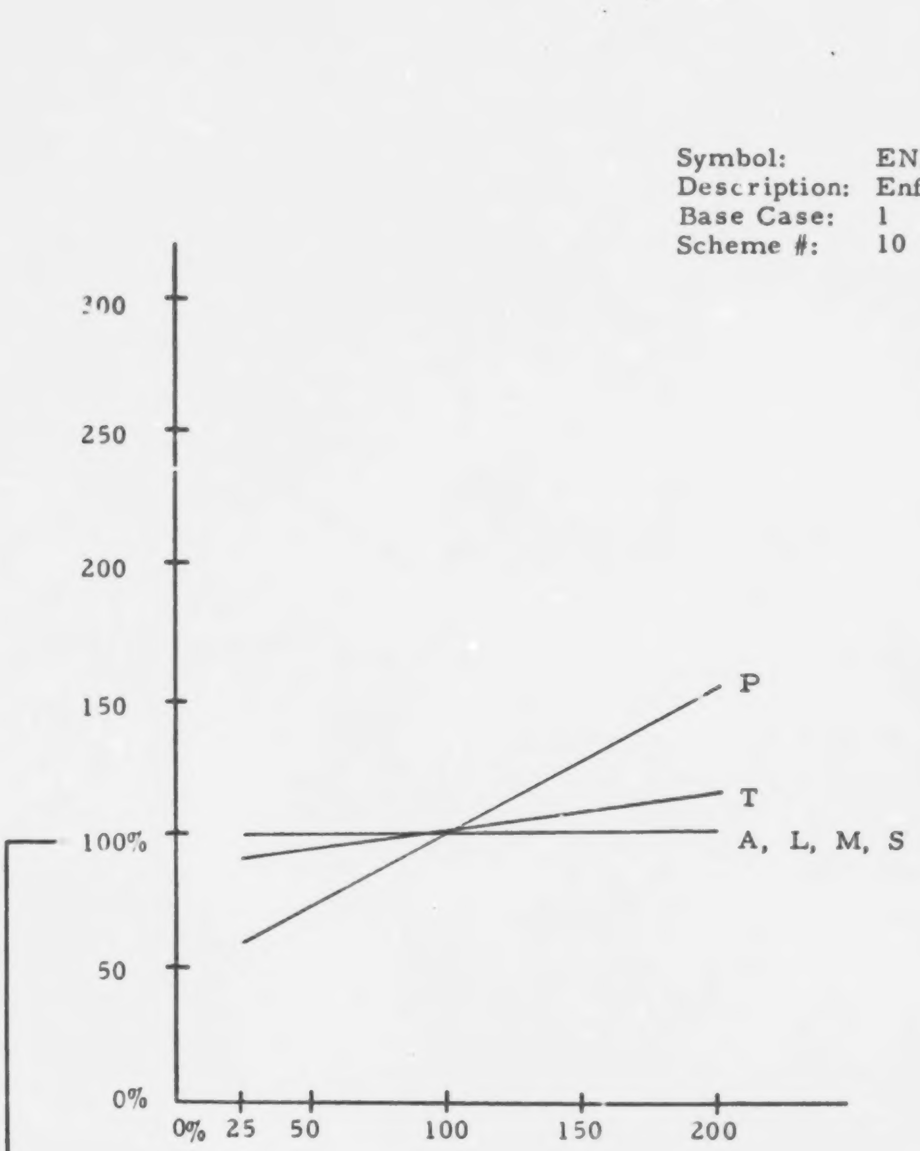
Symbol:	ELECOS
Description:	Electricity Cost
Base Case:	1
Scheme #:	10



A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	0	0
Slope over the range	0	0	0	0	0	0

Symbol: ENFCST
Description: Enforcement Cost
Base Case: 1
Scheme #: 10

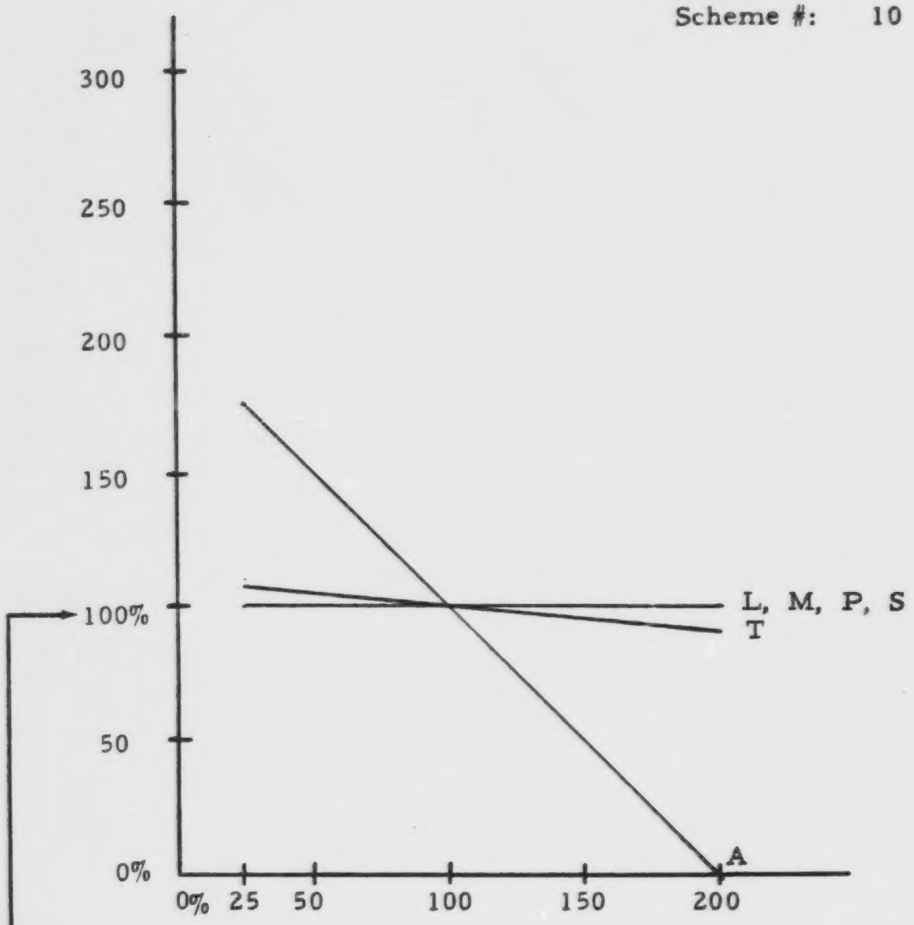


ENFCST - .4 $/cap/yr = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.6	0	.1
Slope over the range	0	0	0	.6	0	.1

Symbol: GOVFF
Description: Government Financing
Base Case: 1
Scheme #: 10

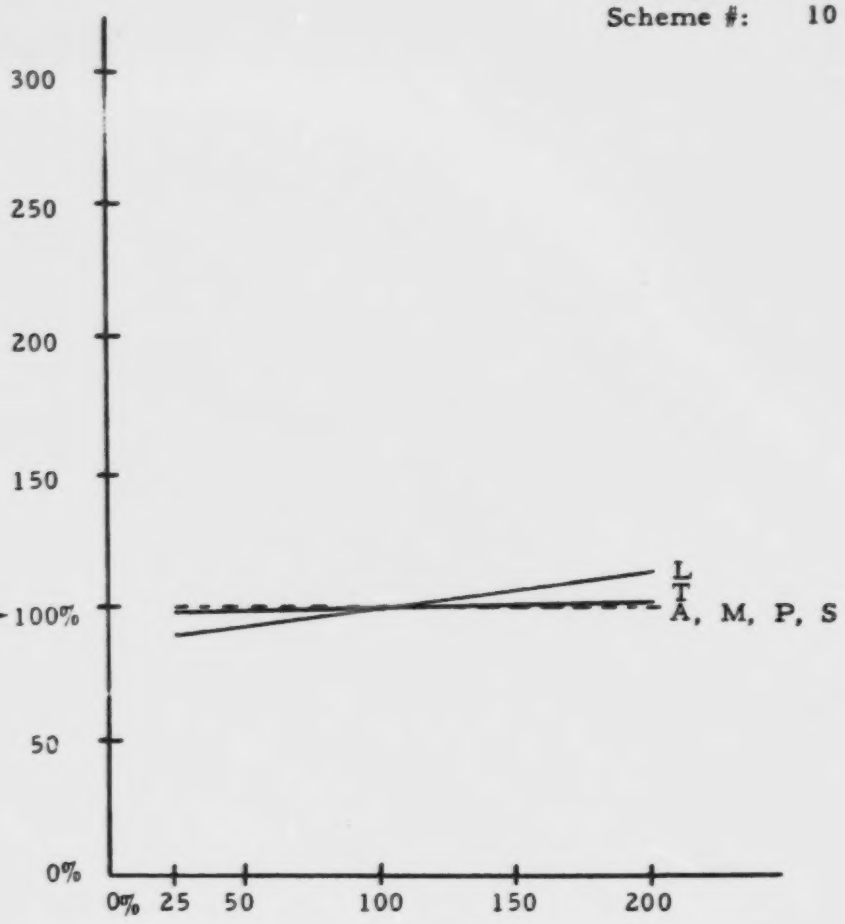


GOVFF - .5 = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-1.	0	0	0	0	-.1
Slope over the range	-1.	0	0	0	0	-.1

Symbol: IDFRAC
Description: Indirect Labor
Base Case: 1
Scheme #: 10

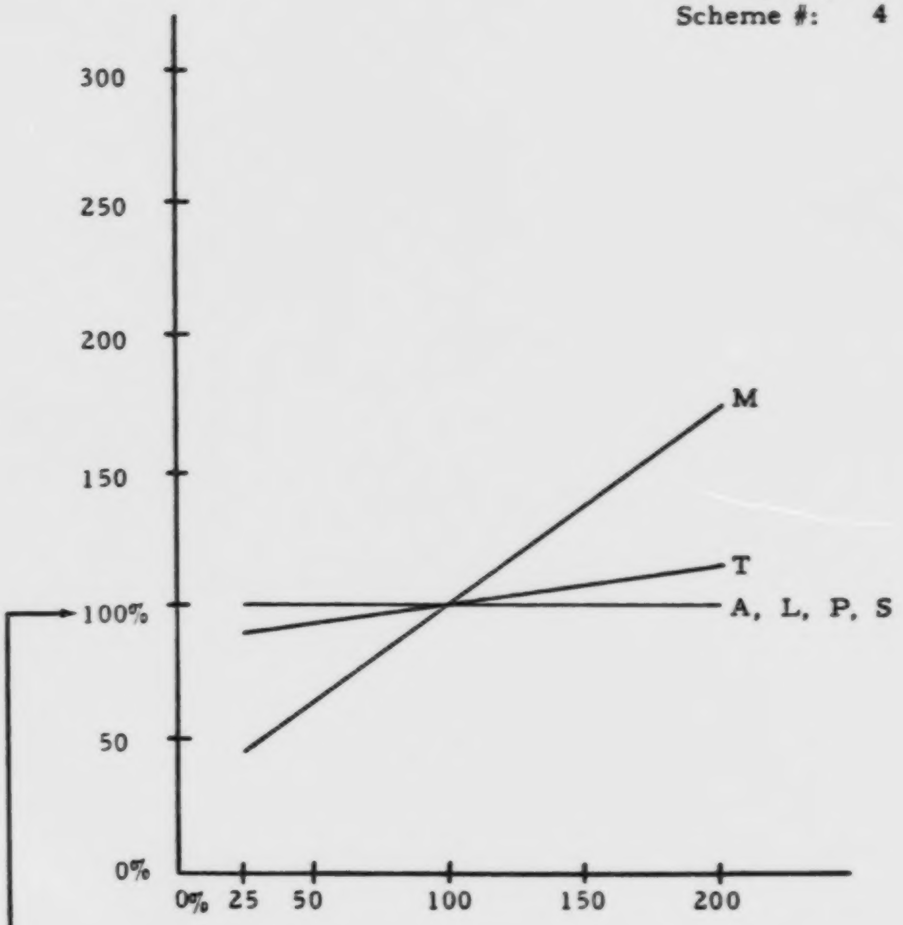


IDFRAC - .15 = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.1	0	0	0	.02
Slope over the range	0	.1	0	0	0	.02

Symbol:	LIMECS
Description:	Lime Cost
Base Case:	1
Scheme #:	4

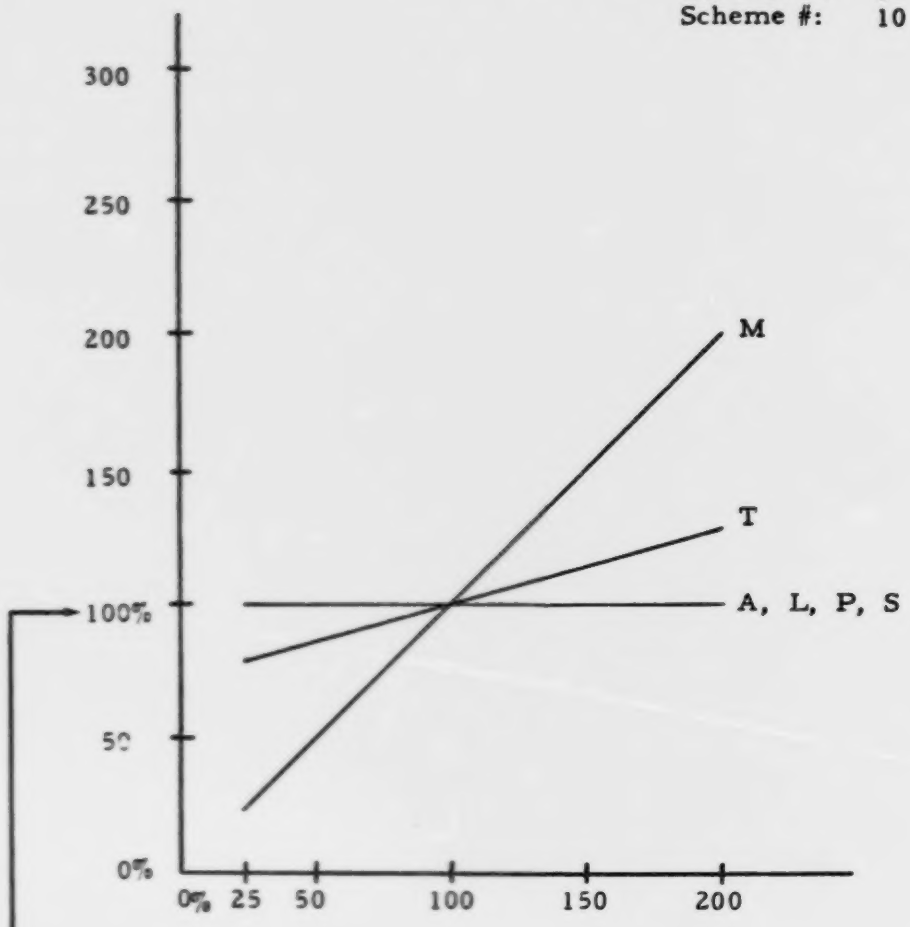


LIMECS - .02 $/LB = 100%

A = Unit Amortization Cost - 0.6 ¢/kgal = 100%
L = Unit Labor Cost - 3.3 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.7 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 8.2 ¢/kgal = 100%
T = Unit Total Cost - 17.9 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.7	0	0	.1
Slope over the range	0	0	.7	0	0	.1

Symbol: MATRLS
Description: Price Index
Base Case: 1
Scheme #: 10

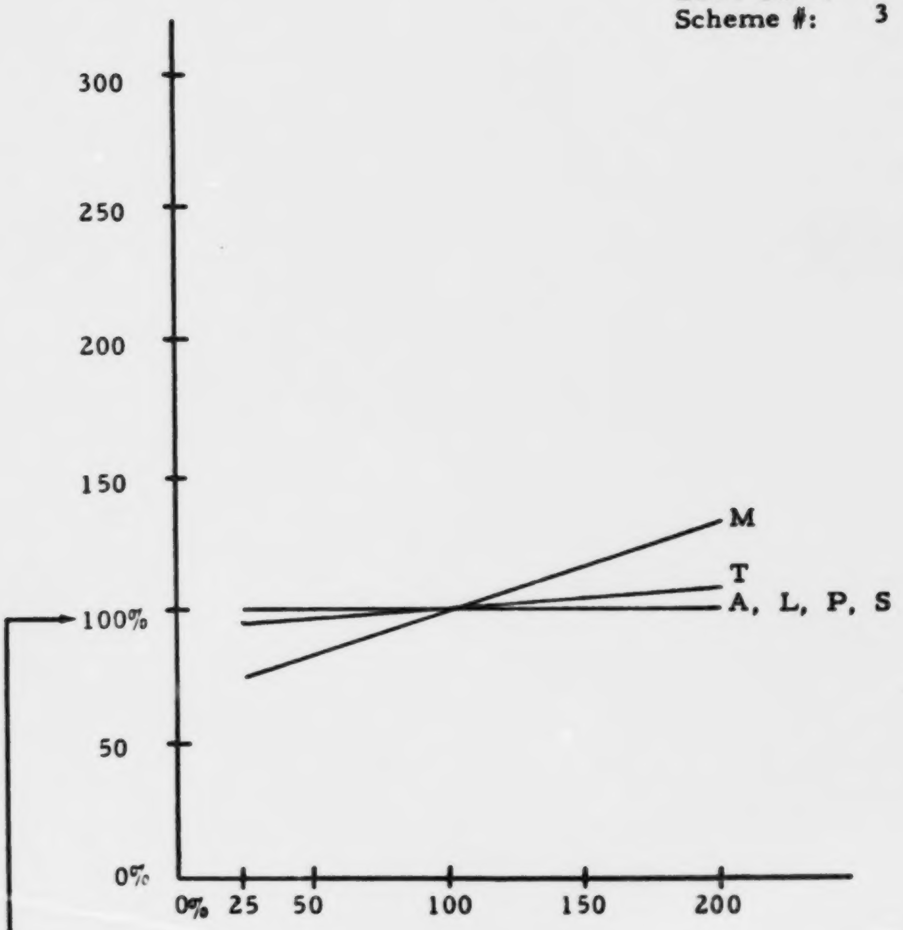


MATRLS - 1.18 = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	1.	0	0	.3
Slope over the range	0	0	1.	0	0	.3

Symbol: PCKLCS
Description: Pickle Liquor Cost
Base Case: 1
Scheme #: 3

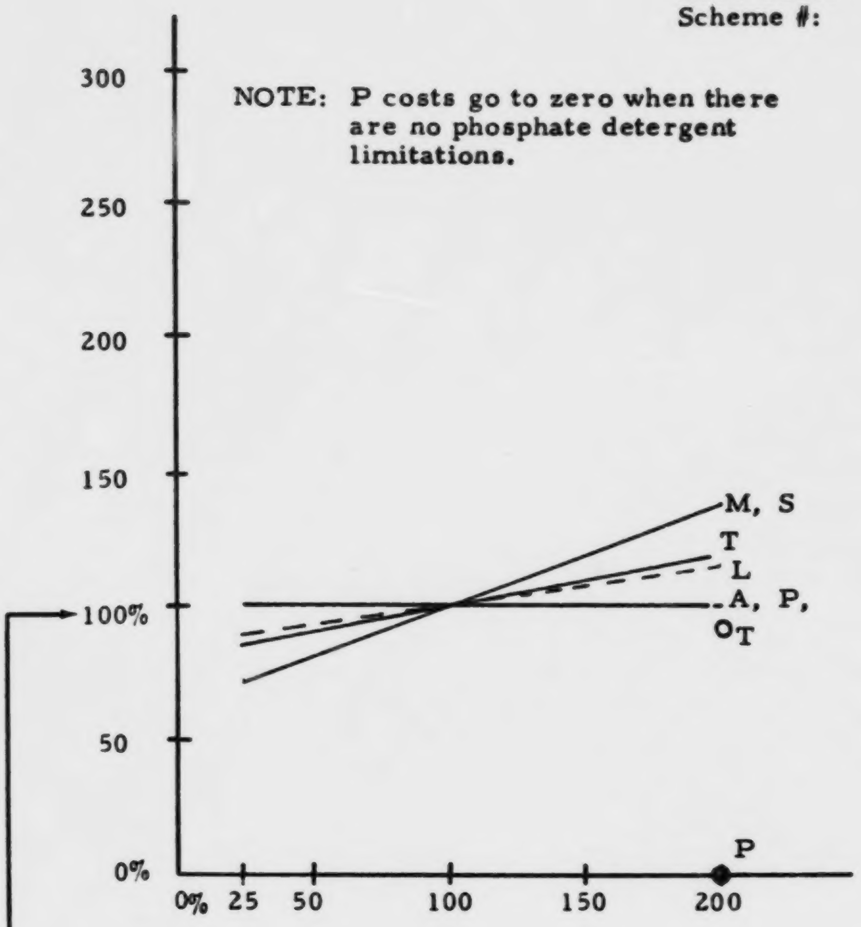


PCKLCS - .04 $/LB = 100%

A = Unit Amortization Cost - 2.6 ¢/kgal = 100%
L = Unit Labor Cost - 4.2 ¢/kgal = 100%
M = Unit Material & Supply Cost - 5.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 10.0 ¢/kgal = 100%
T = Unit Total Cost - 24.2 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.3	0	0	.07
Slope over the range	0	0	.3	0	0	.07

Symbol: PCNTNT
Description: Detergent Phosphorus
Base Case: 1
Scheme #: 10

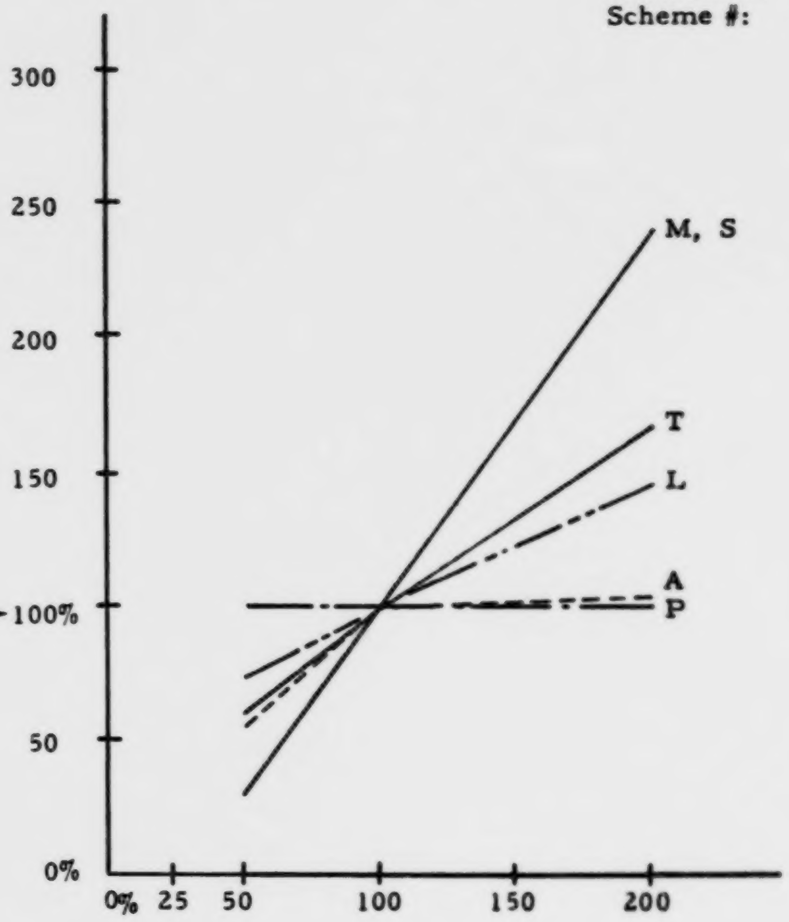


PCNTNT - 0.5 = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.1	.4	0	.4	.2
Slope over the range	0	.1	.4	0	.4	.2

Symbol: PINPS
Description: Influent Phosphorus
Base Case: 1
Scheme #: 10

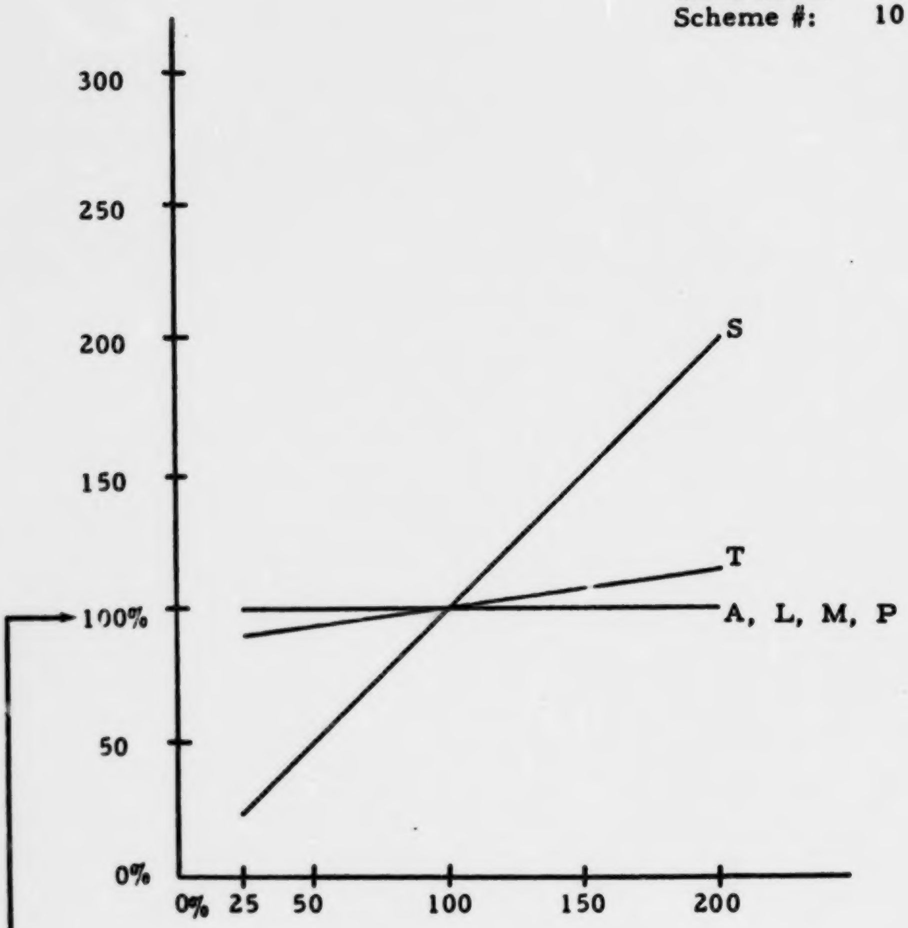


PINPS - 10 mg P/l = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.5	1.4	0	1.4	.7
Slope over the range	0	.5	1.4	0	1.4	.7

Symbol:	TRNCST
Description:	Transportation Cost
Base Case:	1
Scheme #:	10



TRNCST - 5. $/TON-MILE = 100%

A = Unit Amortization Cost - 0.8 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.1 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	1.	.15
Slope over the range	0	0	0	0	1.	.15

CASE 2 - CLINTON, MASS.

Conclusions

The parameter with the greatest effect on the unit costs of treatment was ELIMIT, the phosphorus effluent level. As the effluent level was decreased from 2.0 mg P/l to 0.1 mg P/l the cost of removal went from 7.0¢/kgal to 20.1¢/kgal, an increase in cost of 200%. The next most important was PINPS, the influent phosphorus level. As it was changed from 25% to 200% of its base value of 10. mg P/l, the total cost of removal for the least costly scheme changed from 47% to 172% of its base value of 7.0¢/kgal. Changing MATRLS, the Wholesale Price Index, from 25% to 200% of its base value of May 72 caused the total treatment cost to go from 61% to 152% of its base value. ALUMCS, the cost of alum, was next in influence causing costs to change from 62% to 151% as it went from 25% to 200% of its base value of 3¢/lb. Table 4 contains those parameters which caused one or more sub-measures (costs) to have a sensitivity $\geq |.4|$ ranked by the sensitivity of T, the total cost. Following this are the sensitivity graphs of all of the parameters.

Description

The MDC Clinton, Mass., plant is a 2 MGD trickling filter plant. The sludge undergoes anaerobic digestion before going to the sludge drying beds. After the sludge is dried it is trucked to a landfill site 4 miles away. A complete listing of the input variables and values to the program SARMVE is contained in the appendices along with the plant survey results.

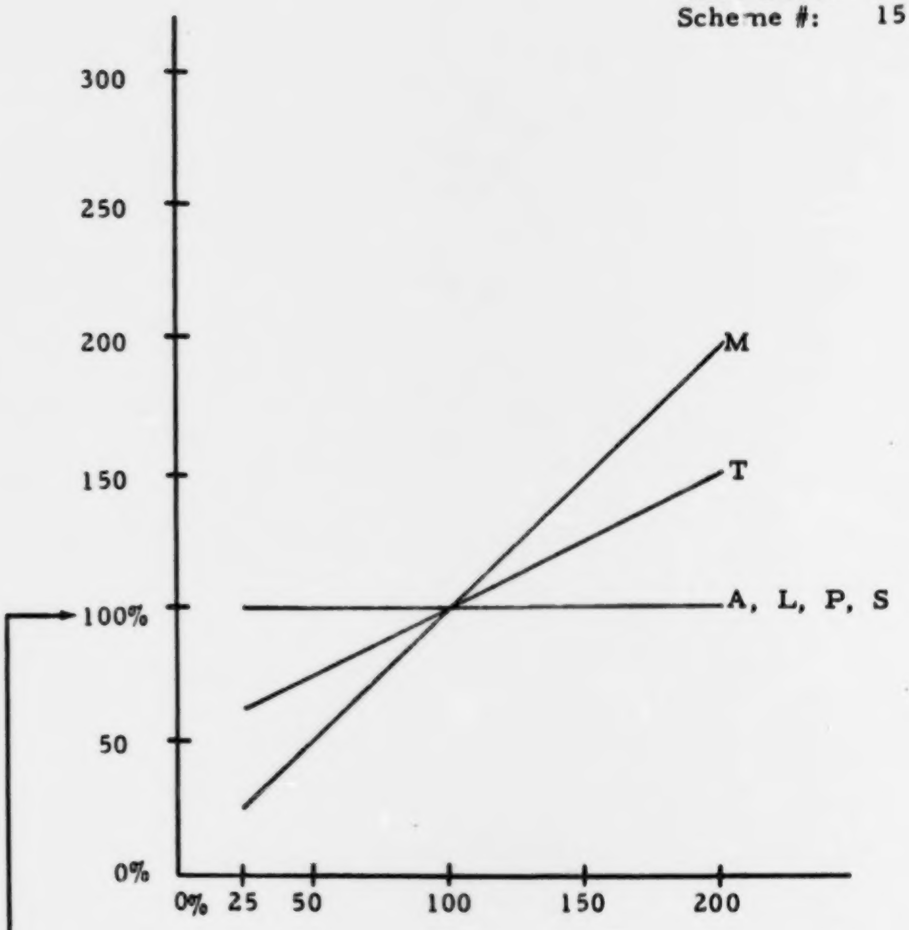
TABLE 4

Sensitivity Ranking - Case 2

	MEASURES					
PARAMETER	T	A	L	M	P	S
ELIMIT	*					
PINPS	.7		.4	1.2		1.2
ALUMCS	.5			1.		
MATRLS	.5			1.		
DHR	.2		1.			
PCKLCS	.2			.8		
AMLIFE	.1	-1.2				
ENFCST	.1				.6	
DIFCOS	.08			.4	.4	
CNSTRC	.07	1.				
GOVFF	-.07	-1.				
DTRGUS	-.04				.4	
AMRATE	.03	.4				
TRNCST	.02					1.

*The sensitivity of ELIMIT is not computed on the basis of percentage change.

Symbol: ALUMCS
Description: Alum Cost
Base Case: 2
Scheme #: 15

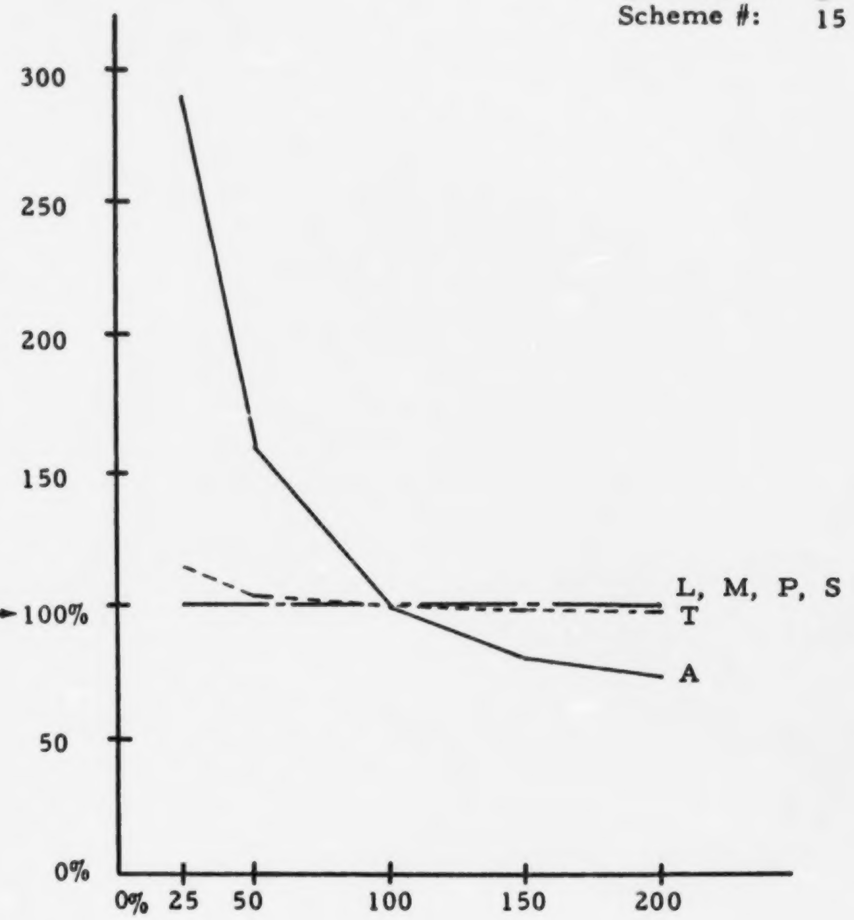


ALUMCS - .03 $/LB = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	1.	0	0	.5
Slope over the range	0	0	1.	0	0	.5

Symbol: AMLIFE
Description: Amortization Lifetime
Base Case: 2
Scheme #: 15

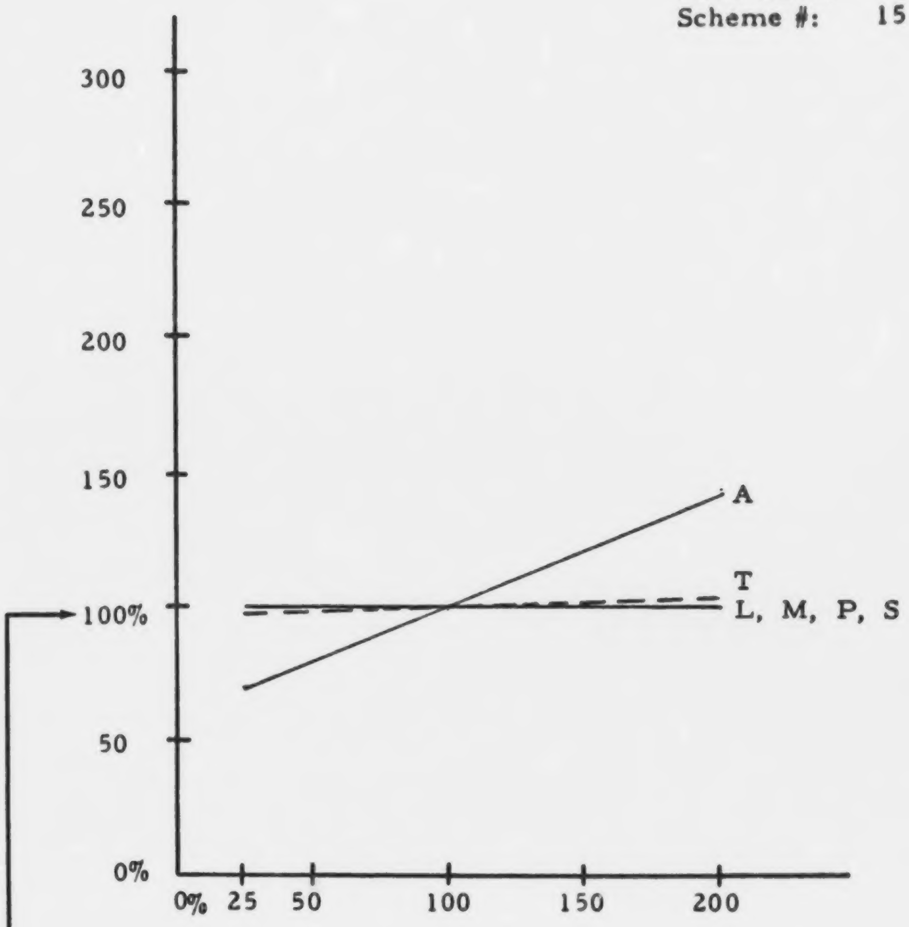


AMLIFE - 20 YEARS = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-0.8	0	0	0	0	.1
Slope over the range	-1.2	0	0	0	0	.1

Symbol: AMRATE
Description: Amortization Rate
Base Case: 2
Scheme #: 15

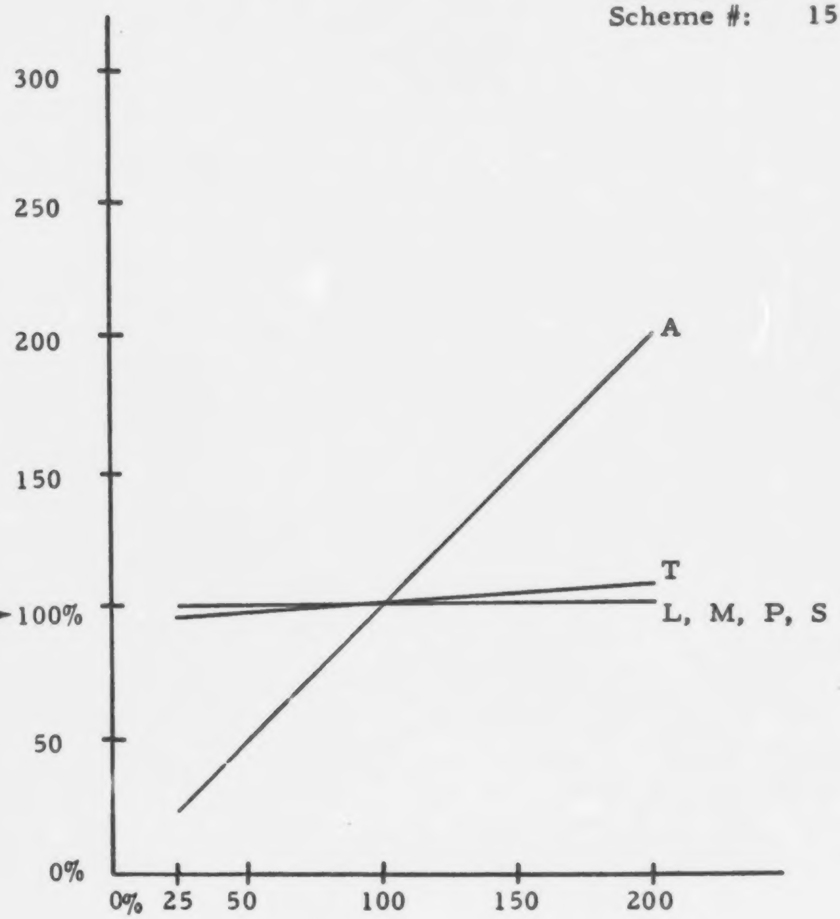


AMRATE - .05 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.4	0	0	0	0	.03
Slope over the range	.4	0	0	0	0	.03

Symbol: CNSTRC
Description: WQO-STP Index
Base Case: 2
Scheme #: 15

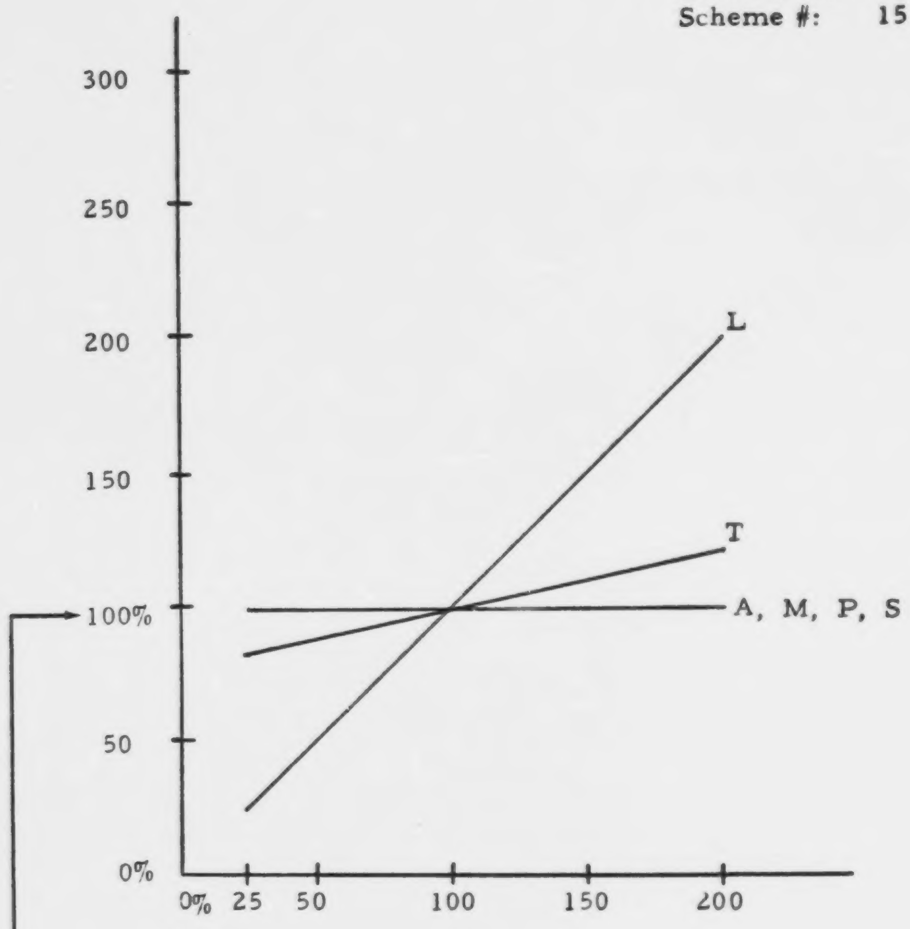


CNSTRC - 1.714 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	1.	0	0	0	0	.07
Slope over the range	1.	0	0	0	0	.07

Symbol: DHR
Description: Labor Rate
Base Case: 2
Scheme #: 15

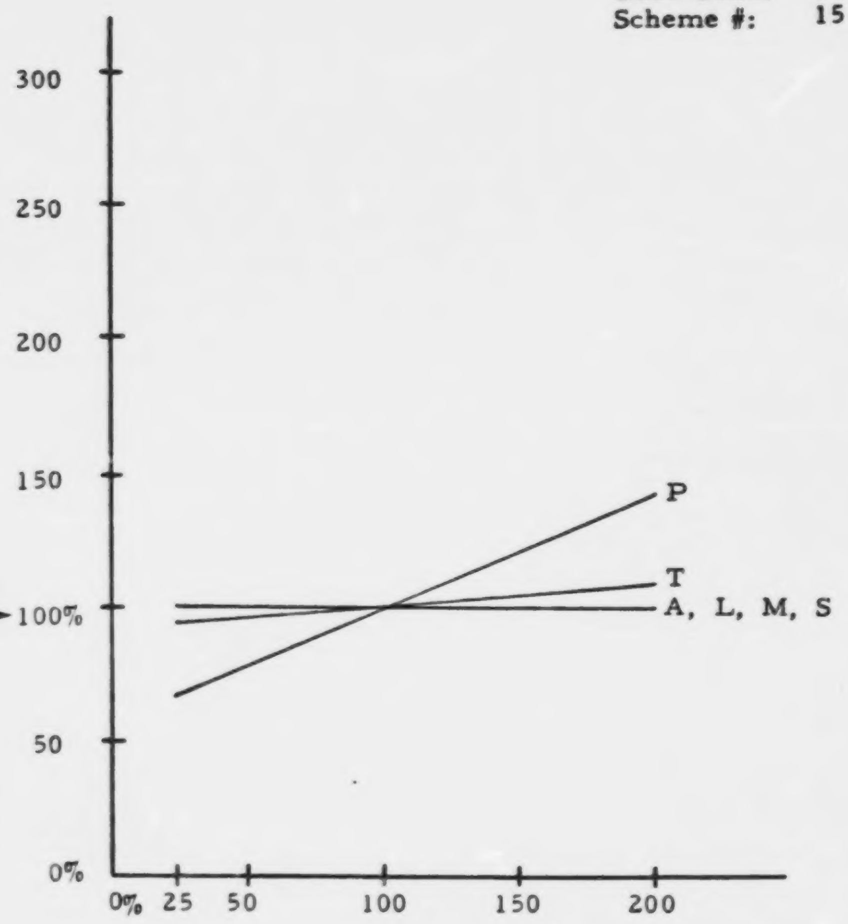


DHR - 4.10 $/HR = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	1.	0	0	0	.2
Slope over the range	0	1.	0	0	0	.2

Symbol:	DIFCOS
Description:	Detergent Cost
Base Case:	2
Scheme #:	15

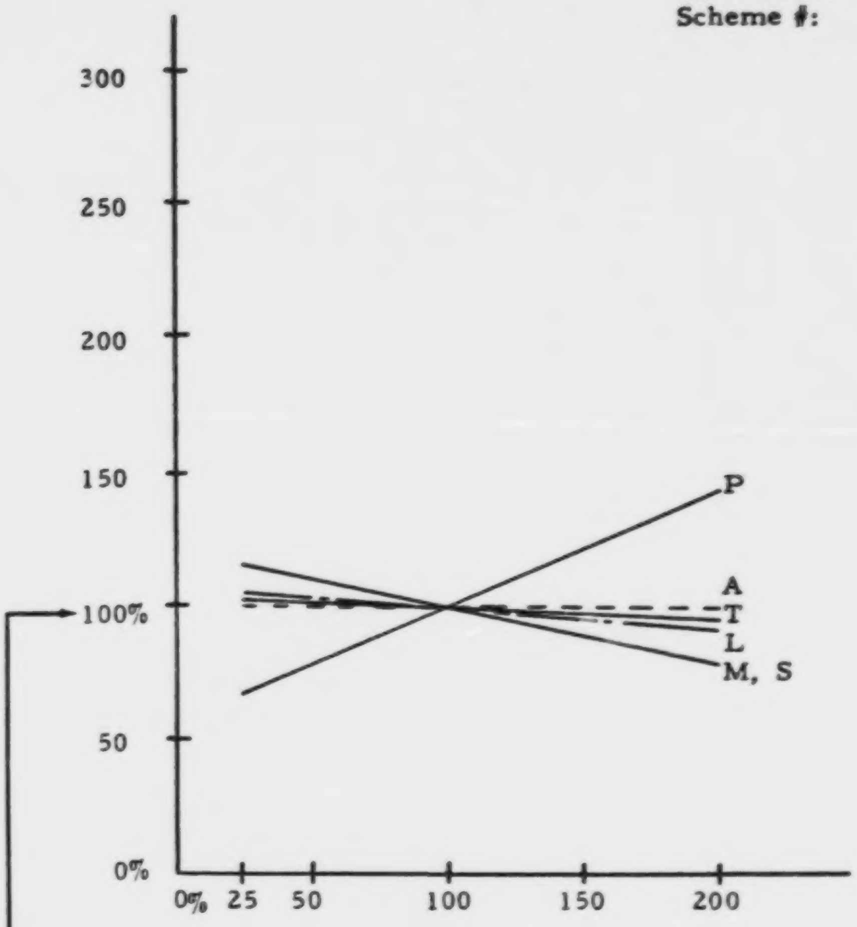


DIFCOS - .02 $/LB = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.4	0	.08
Slope over the range	0	0	0	.4	0	.08

Symbol: DTRGUS
Description: Detergent Use
Base Case: 2
Scheme #: 15

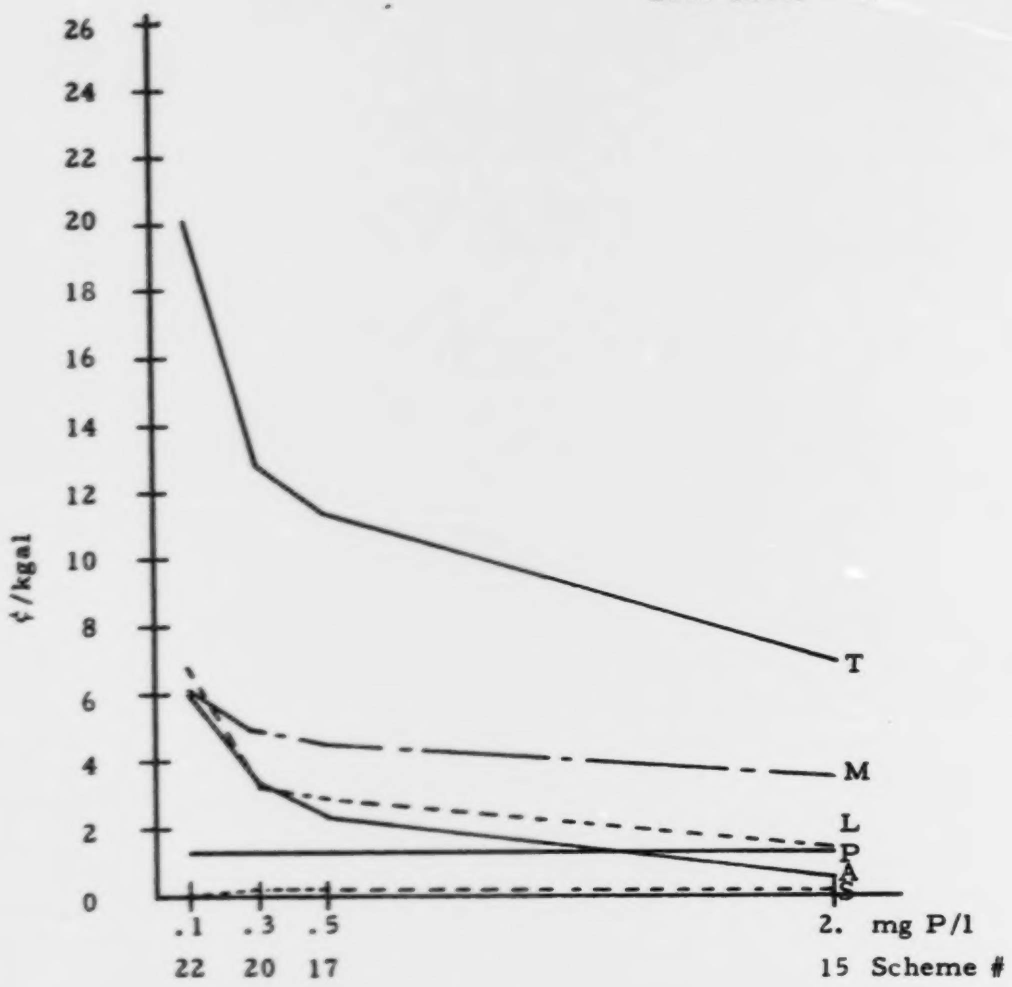


DTRGUS - 16 lb/capita/yr = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

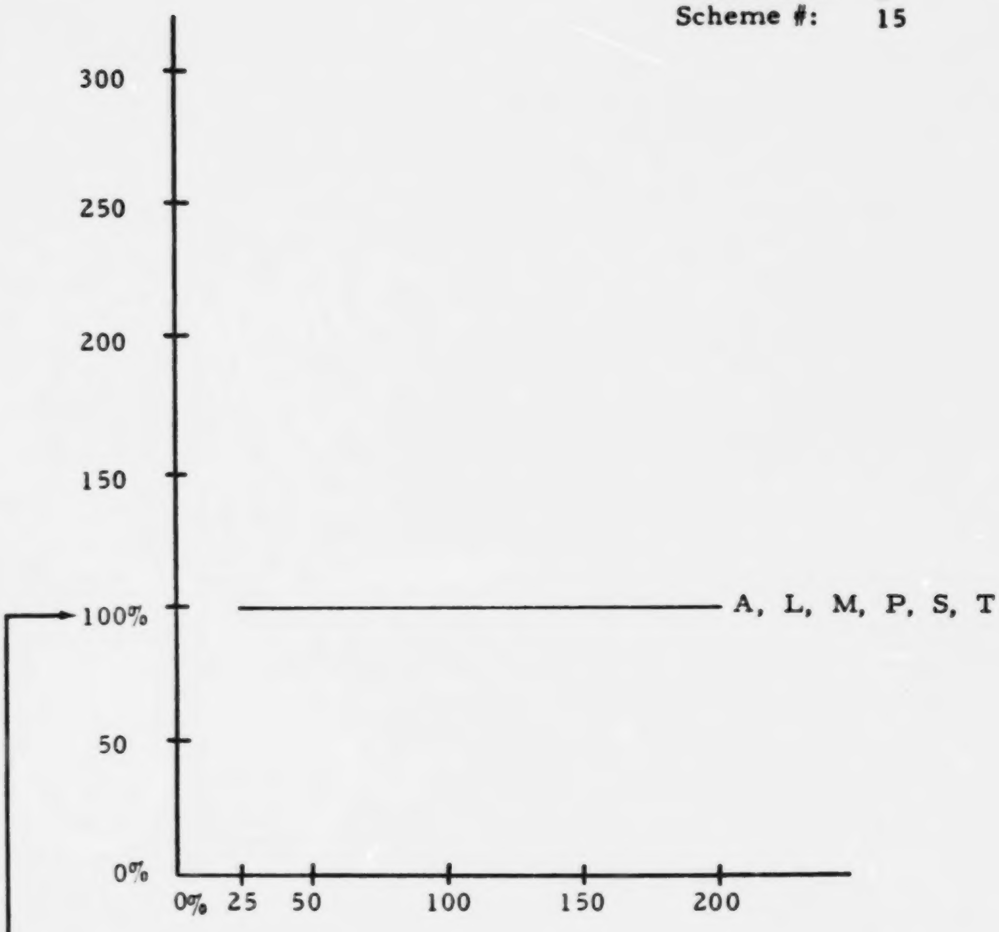
	A	L	M	P	S	T
Sensitivity at base point	0	-.07	-.2	.4	-.2	-.04
Slope over the range	0	-.07	-.2	.4	-.2	-.04

Symbol: ELIMIT
Description: Effluent Limit
Base Case: 2



A = Unit Amortization Cost
L = Unit Labor Cost
M = Unit Material & Supply Cost
P = Unit Detergent Limitation Cost
S = Unit Solid Sink Cost
T = Unit Total Cost

Symbol: ELECOS
Description: Electricity Cost
Base Case: 2
Scheme #: 15

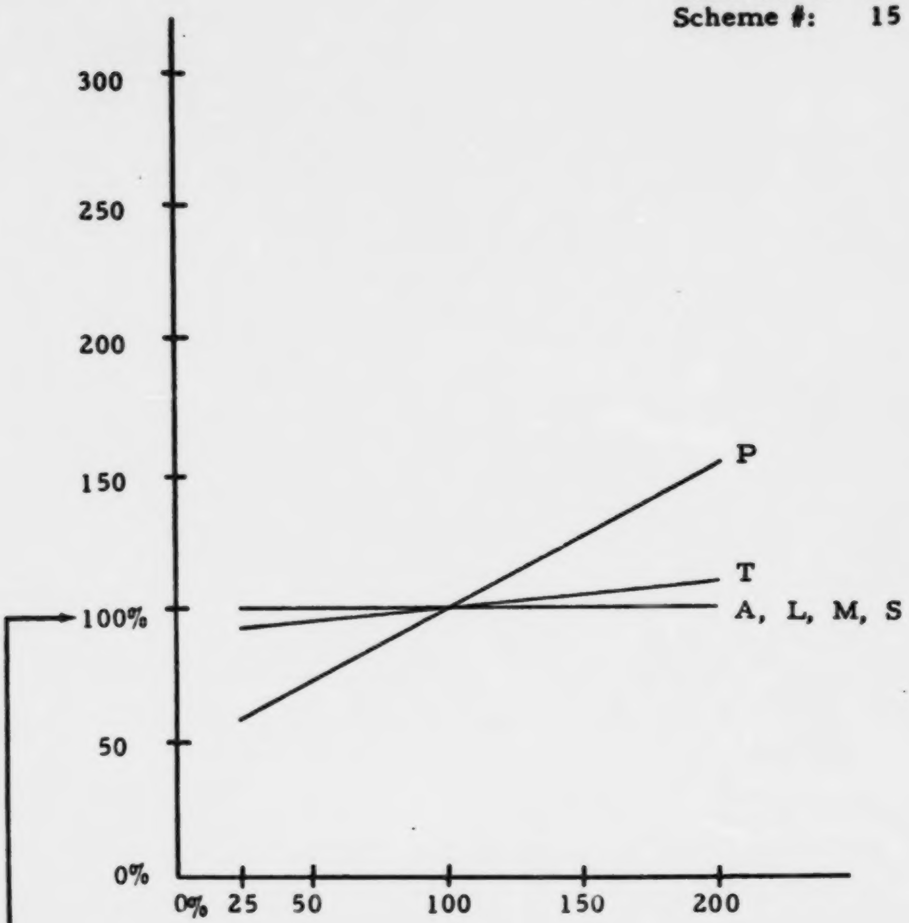


ELECOS - .0175 $/KWHR = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	0	0
Slope over the range	0	0	0	0	0	0

Symbol: ENFCST
Description: Enforcement Cost
Base Case: 2
Scheme #: 15

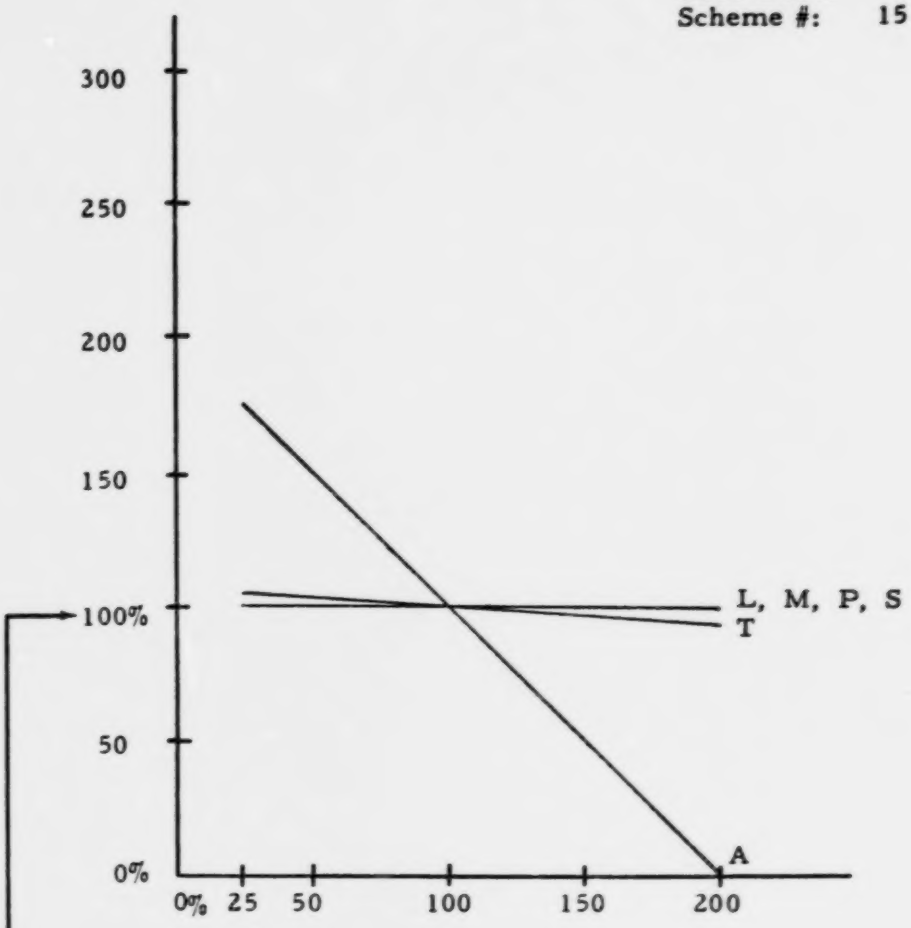


ENFCST - .4 $/capita/yr = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢. kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.6	0	.1
Slope over the range	0	0	0	.6	0	.1

Symbol: GOVFF
Description: Government Financing
Base Case: 2
Scheme #: 15

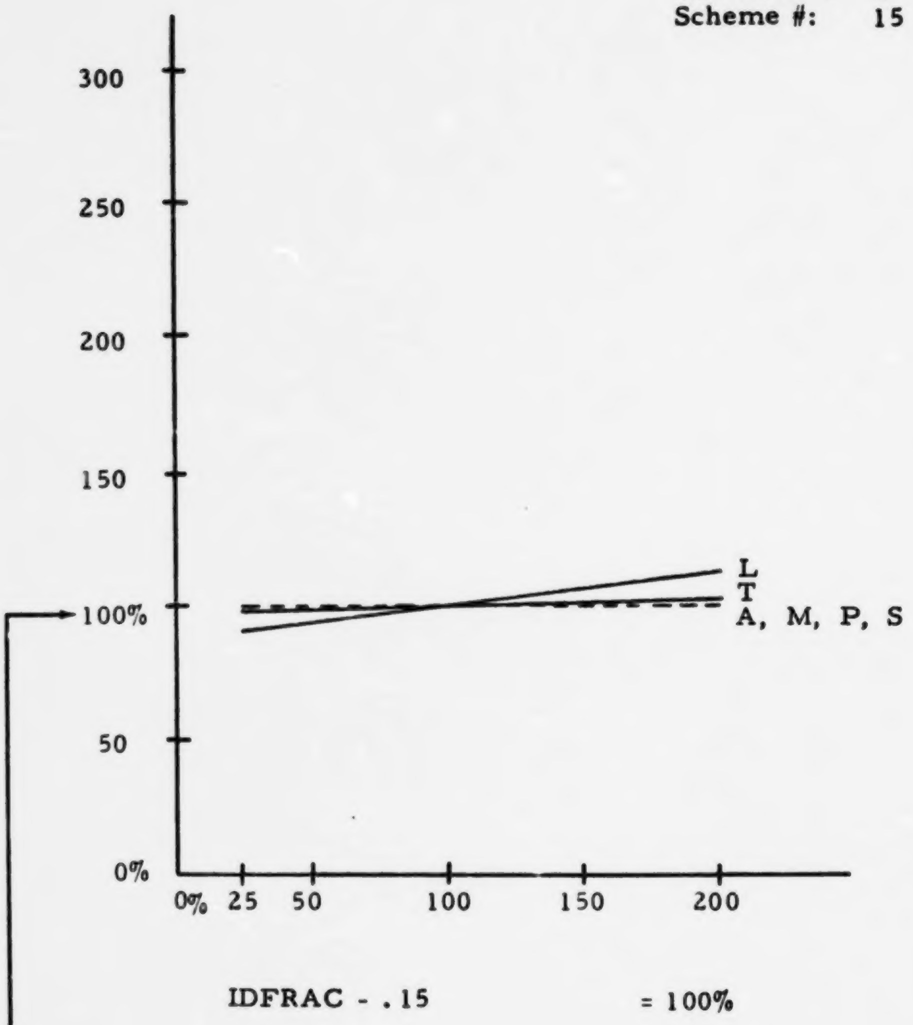


GOVFF - .5 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-1.	0	0	0	0	-.07
Slope over the range	-1.	0	0	0	0	-.07

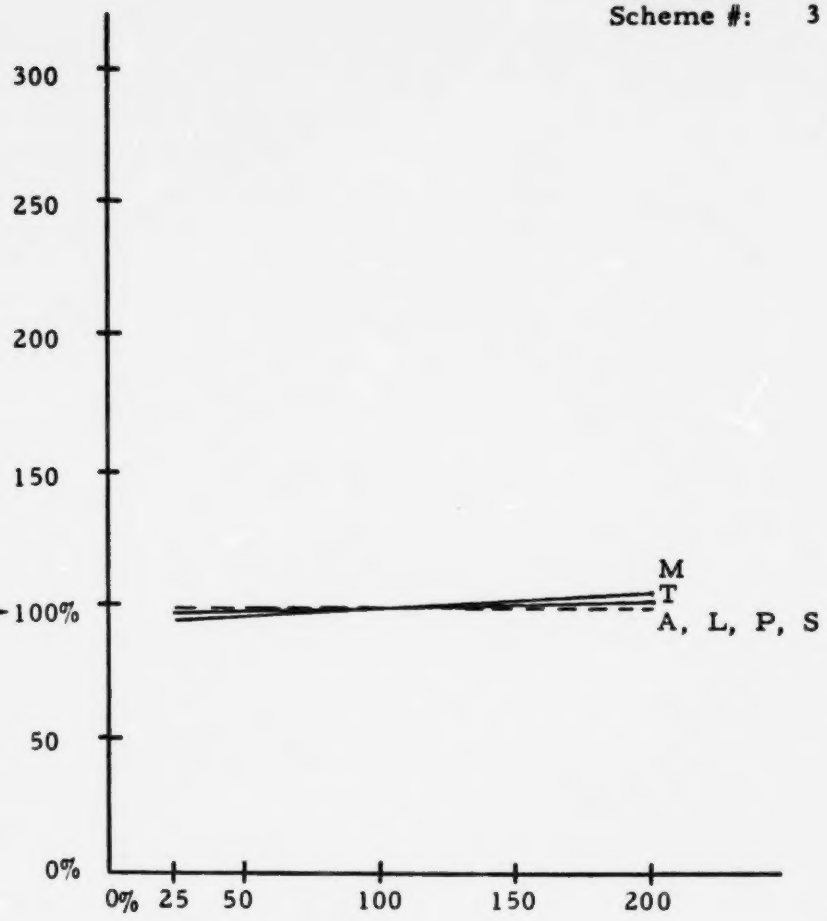
Symbol: IDFRAC
Description: Indirect Labor
Base Case: 2
Scheme #: 15



A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.1	0	0	0	.03
Slope over the range	0	.1	0	0	0	.03

Symbol: LIMECS
Description: Lime Cost
Base Case: 2
Scheme #: 3

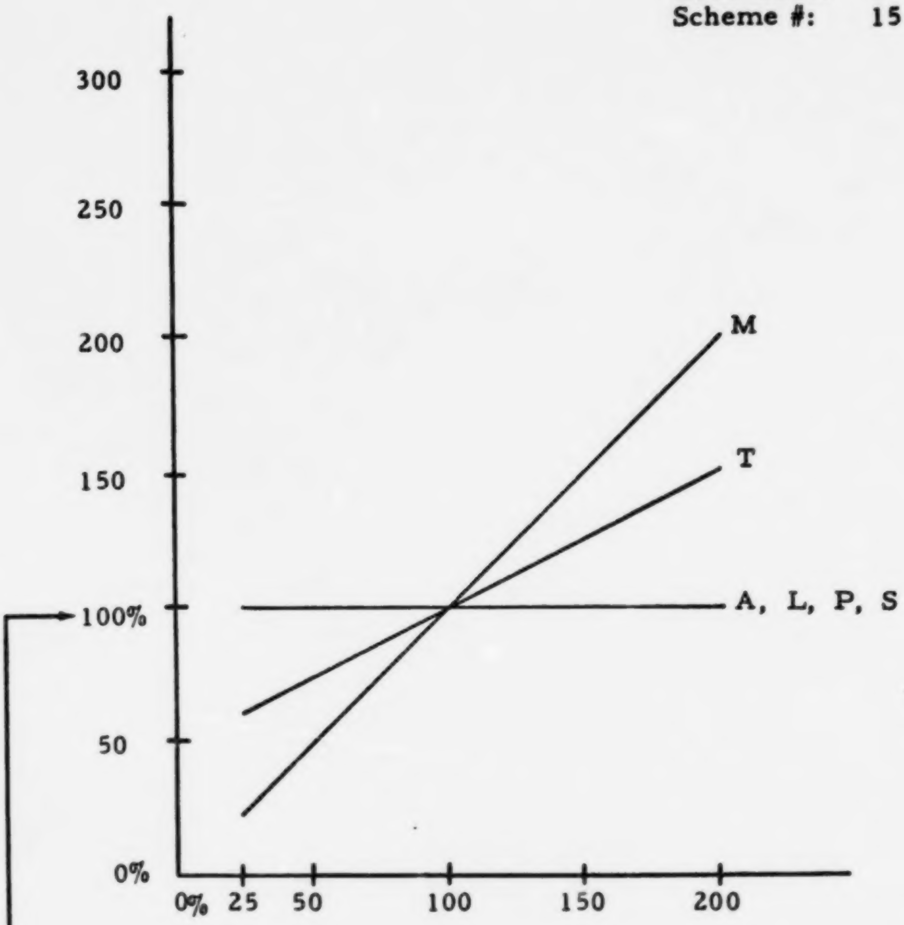


LIMECS - .01 $/LB = 100%

A = Unit Amortization Cost - 0.6 ¢/kgal = 100%
L = Unit Labor Cost - 5.8 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.7 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.4 ¢/kgal = 100%
T = Unit Total Cost - 11.8 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.05	0	0	.01
Slope over the range	0	0	.05	0	0	.01

Symbol: MATRLS
Description: Wholesale Price Index
Base Case: 2
Scheme #: 15

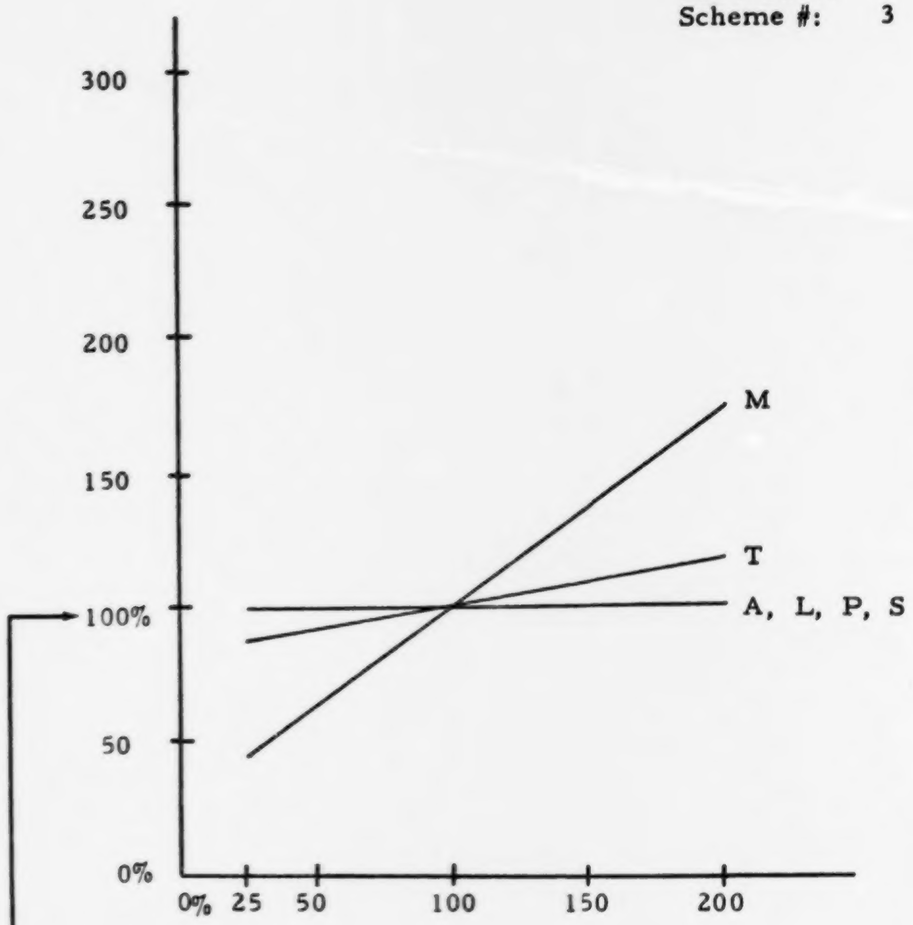


MATRLS - 1.18 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	1.	0	0	.5
Slope over the range	0	0	1.	0	0	.5

Symbol: PCKLCS
Description: Pickle Liquor Cost
Base Case: 2
Scheme #: 3

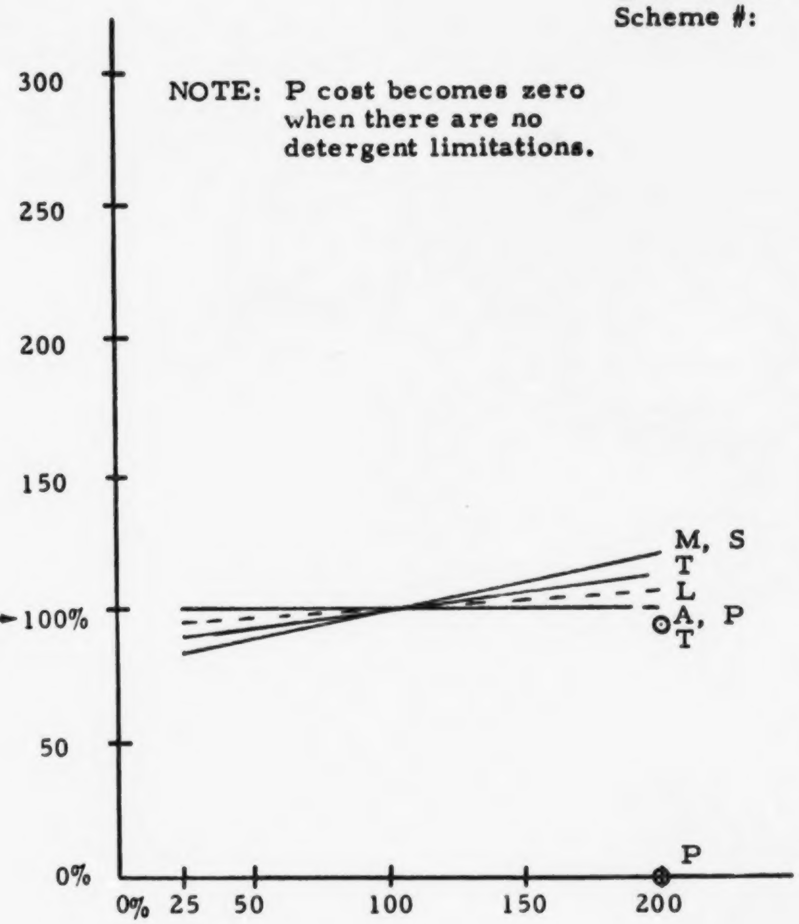


PCKLCS - .04 $/LB = 100%

A = Unit Amortization Cost - 0.6 ¢/kgal = 100%
L = Unit Labor Cost - 5.8 ¢/kgal = 100%
M = Unit Material & Supply Cost - 2.7 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 1.4 ¢/kgal = 100%
T = Unit Total Cost - 11.8 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.8	0	0	.2
Slope over the range	0	0	.8	0	0	.2

Symbol: PCNTNT
Description: Detergent Phosphorus
Base Case: 2
Scheme #: 15



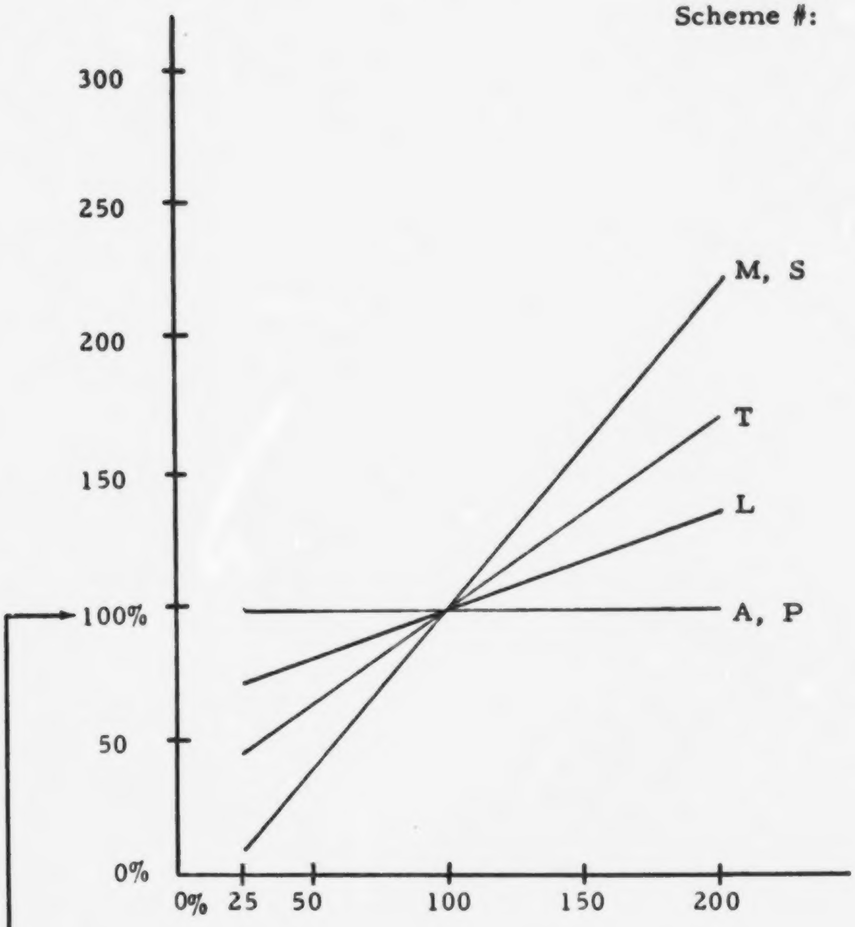
NOTE: P cost becomes zero when there are no detergent limitations.

PCNTNT - .05 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.07	.2	0	.2	.13
Slope over the range	0	.07	.2	0	.2	.13

Symbol: PINPS
Description: Influent Phosphorus
Base Case: 2
Scheme #: 15

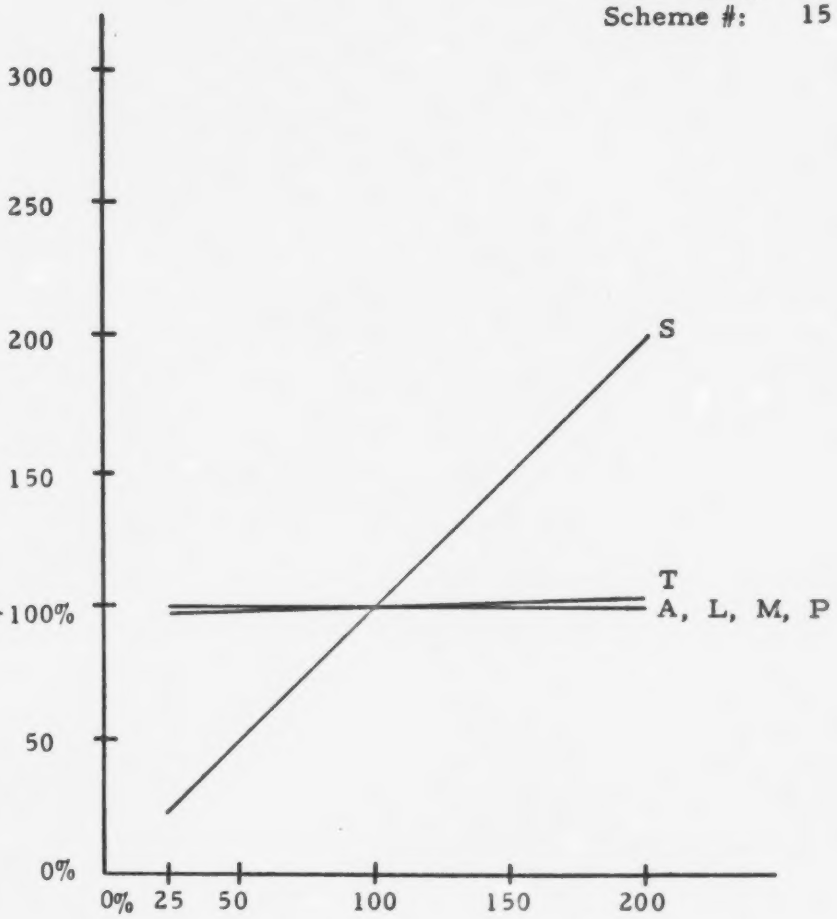


PINPS - 10 mg P/l = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.4	1.2	0	1.2	.7
Slope over the range	0	.4	1.2	0	1.2	.7

Symbol: TRNCST
Description: Transportation Cost
Base Case: 2
Scheme #: 15



TRNCST - 1.5 $/TON-MILE= 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.1 ¢/kgal = 100%
T = Unit Total Cost - 7.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	1.	.02
Slope over the range	0	0	0	0	1.	.02

CASE 3 - TRICKLING FILTER

Conclusions

The parameter with the greatest effect on the unit costs of treatment was ELIMIT, the phosphorus effluent level. As the effluent level was decreased from 2.0 mg P/l to 0.1 mg P/l the cost of removal went from 7.5¢/kgal to 15.5¢/kgal, an increase in cost of 100%. The next most important parameter was PINPS, the influent phosphorus level. As it was changed from 50% to 200% of its base value of 10. mg P/l, the total cost of removal for the least costly scheme change from 61% to 177% of its base value of 7.5¢/kgal. Changing MATRLS, the Wholesale Price Index, from 25% to 200% of its base value of May 72 caused the total treatment cost to go from 64% to 148% of its base value. ALUMCS, the cost of alum, was next in influence causing costs to change from 68% to 143% as it went from 25% to 200% of its base of 3¢/lb. Table 5 contains those parameters which caused one or more sub-measures (costs) to have sensitivity ≥ 1.41 ranked by the sensitivity of T, the total cost. Following this are the sensitivity graphs of all of the parameters.

Description

This trickling filter plant of 5 MGD was designed using the theory incorporated in the model REMOVE. The sludge is thickened by gravity and vacuum filtered before being sent to a landfill site 5 miles away. A complete listing of the input variables and values of the program SARMVE is contained in the appendices.

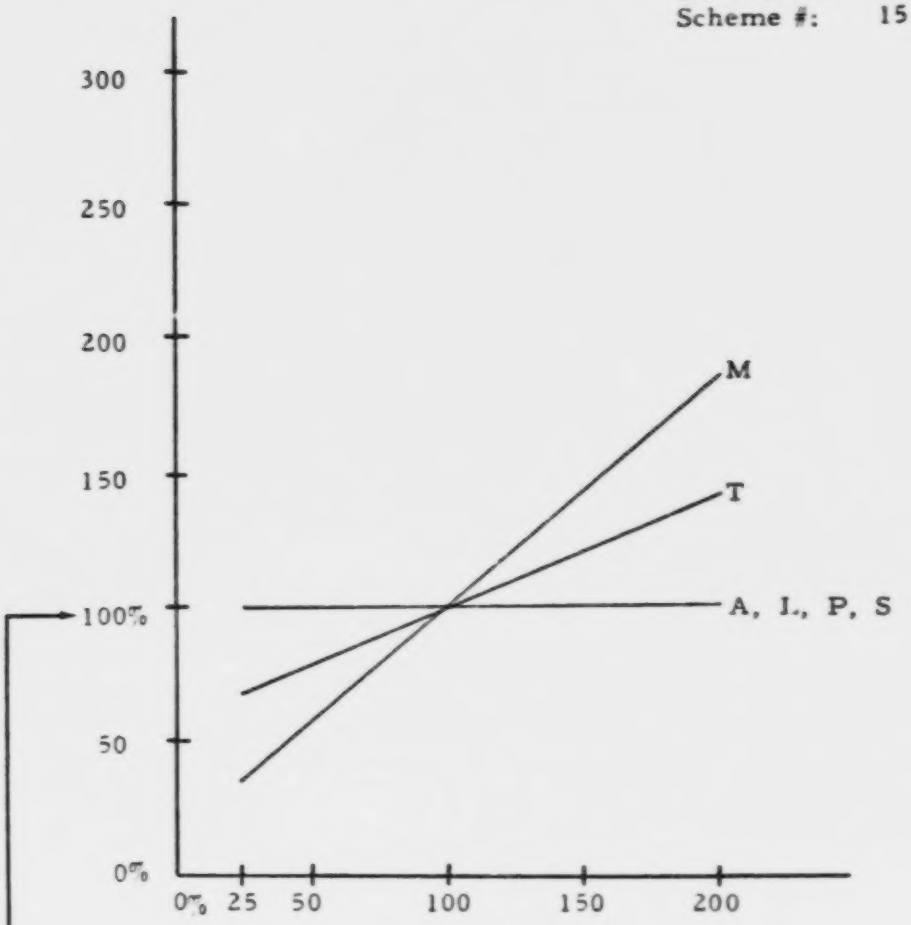
TABLE 5

Sensitivity Ranking - Case 3

PARAMETER	MEASURES T	A	L	M	P	S
ELIMIT	*					
PINPS	.8	.5	.4	1.3		1.3
MATRLS	.5			1.		
ALUMCS	.4			.9		
PCNTNT	.2			.4		.4
ENFCST	.15				.6	
DHR	.13		1.			
DIFCOS	.12				.4	
DTRGUS	-.1			-.4	+.4	-.4
PCKLCS	.1			.4		
CNSTRC	.06	1.				
GOVFF	-.06	-1.				
TRNCST	.06					1.
AMRATE	.03	.4				
AMLIFE	.02	-1.2				

*The sensitivity of ELIMIT is not computed on the basis of percentage change.

Symbol: ALUMCS
Description: Alum Cost
Base Case: 3
Scheme #: 15

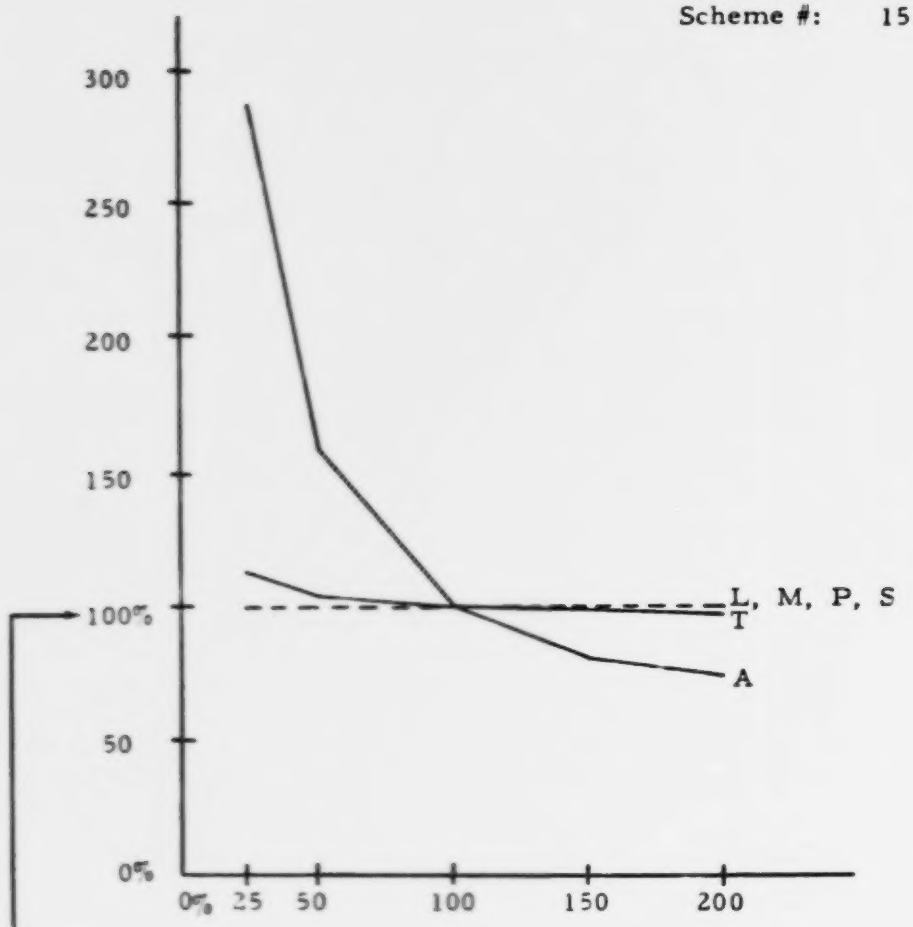


ALUMCS - .03 $/LB = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.9	0	0	.4
Slope over the range	0	0	.9	0	0	.4

Symbol: AMLIFE
Description: Amortization Life
Base Case: 3
Scheme #: 15

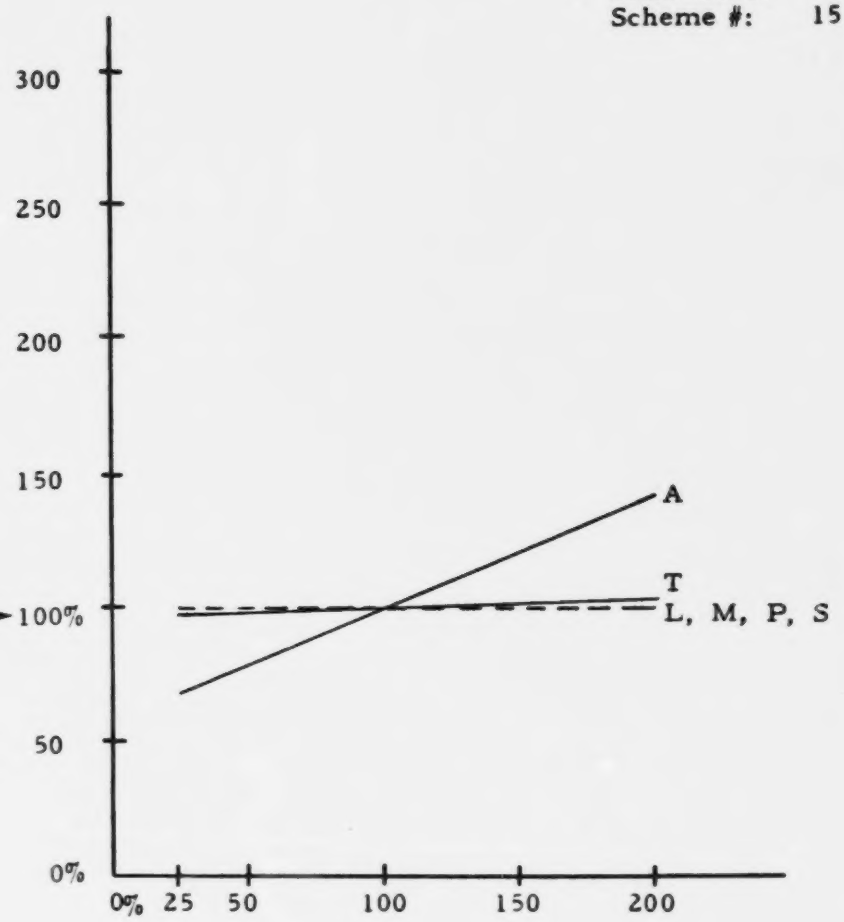


AMLIFE - 20 YEARS = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-0.8	0	0	0	0	-.08
Slope over the range	-1.2	0	0	0	0	-.02

Symbol: AMRATE
Description: Amortization Rate
Base Case: 3
Scheme #: 15

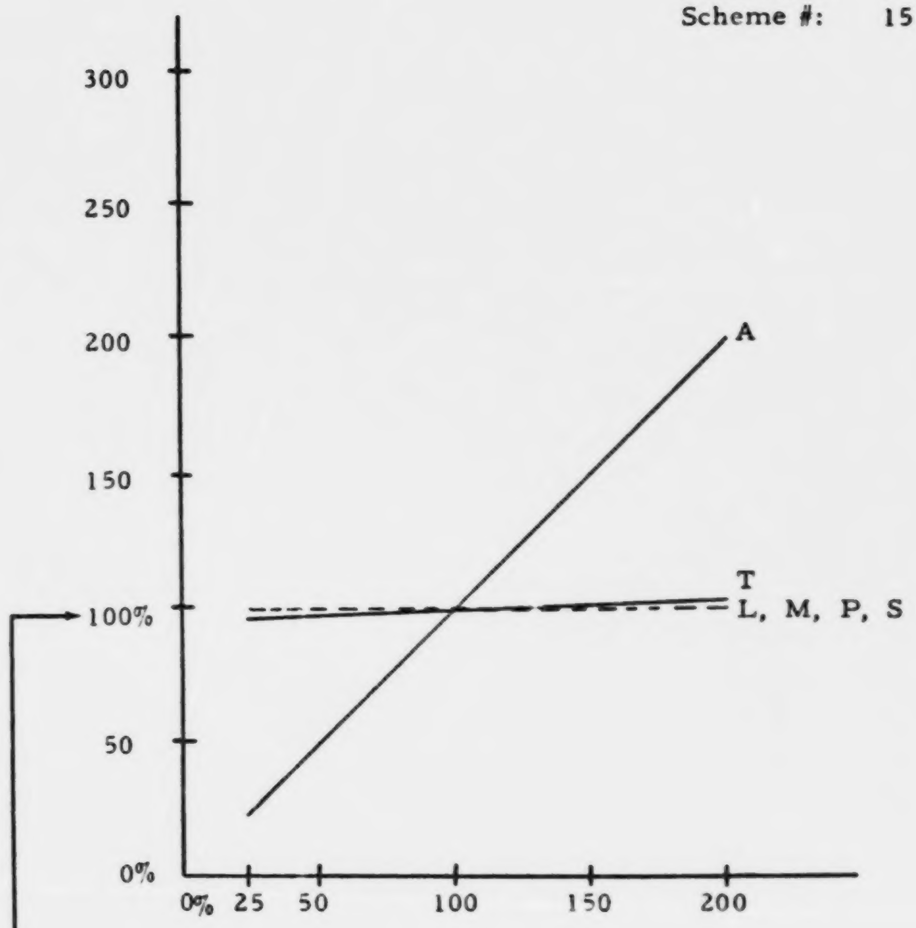


AMRATE - 0.5 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T - Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.4	0	0	0	0	.03
Slope over the range	.4	0	0	0	0	.03

Symbol: CNSTRC
Description: WQO-STP Index
Base Case: 3
Scheme #: 15

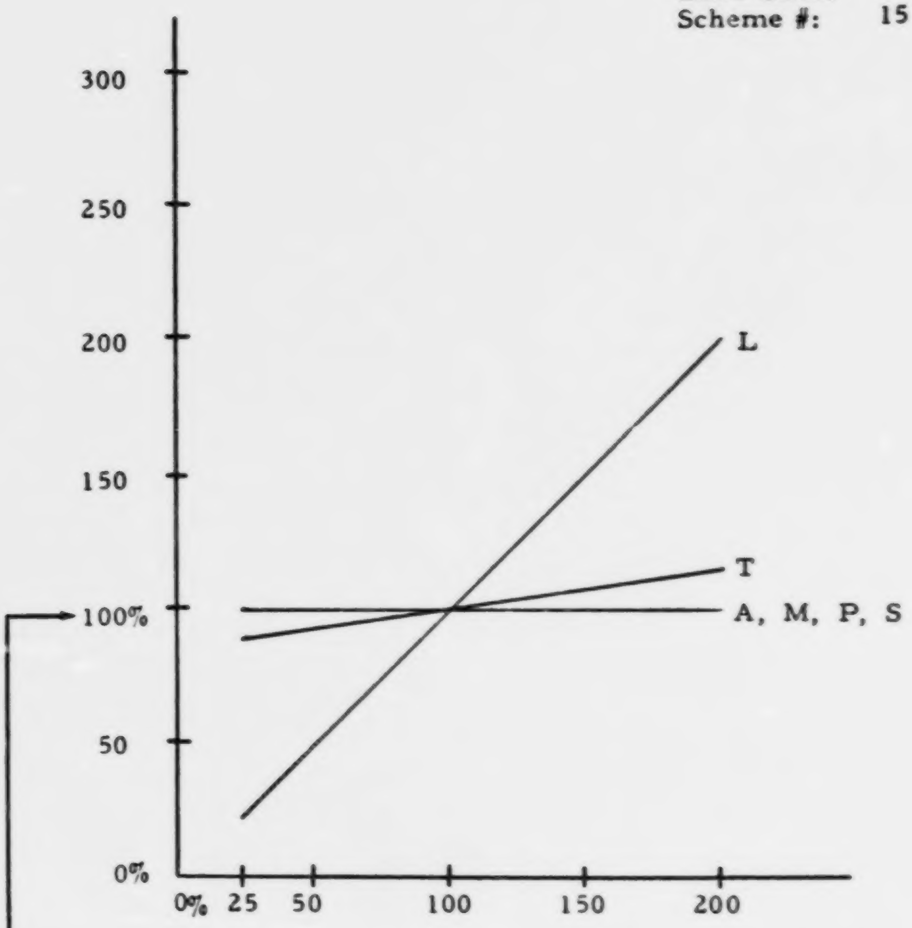


CNSTRC - 1.71 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	1.	0	0	0	0	.06
Slope over the range	1.	0	0	0	0	.06

Symbol: DHR
Description: Labor Rate
Base Case: 3
Scheme #: 15

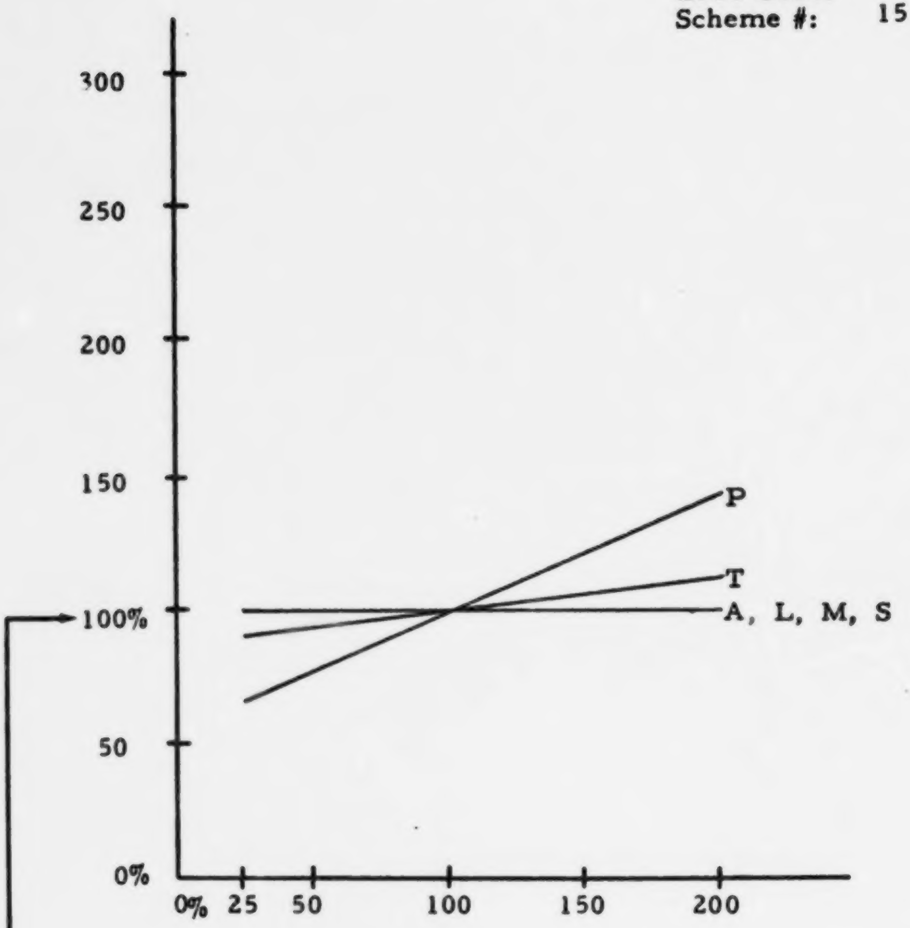


DHR - 3.95 $/HOUR = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	1.	0	0	0	.13
Slope over the range	0	1.	0	0	0	.13

Symbol: DIFCOS
Description: Detergent Cost
Base Case: 3
Scheme #: 15

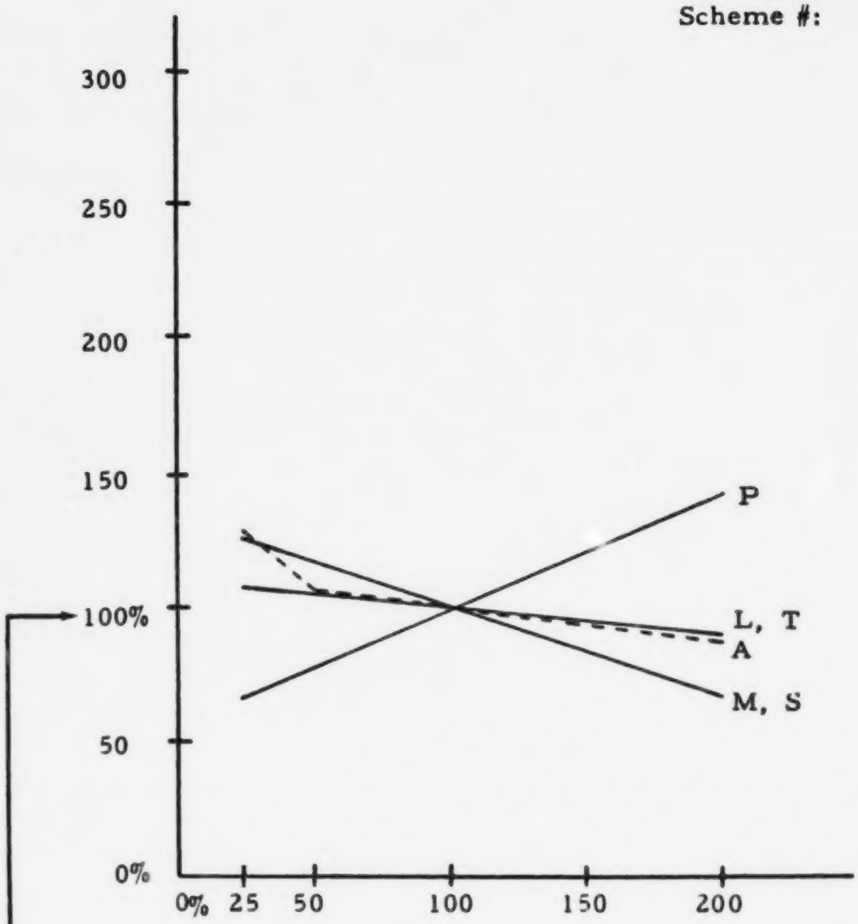


DIFCOS - .02 $/LB = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.4	0	.12
Slope over the range	0	0	0	.4	0	.12

Symbol: DTRGUS
Description: Detergent Use
Base Case: 3
Scheme #: 15

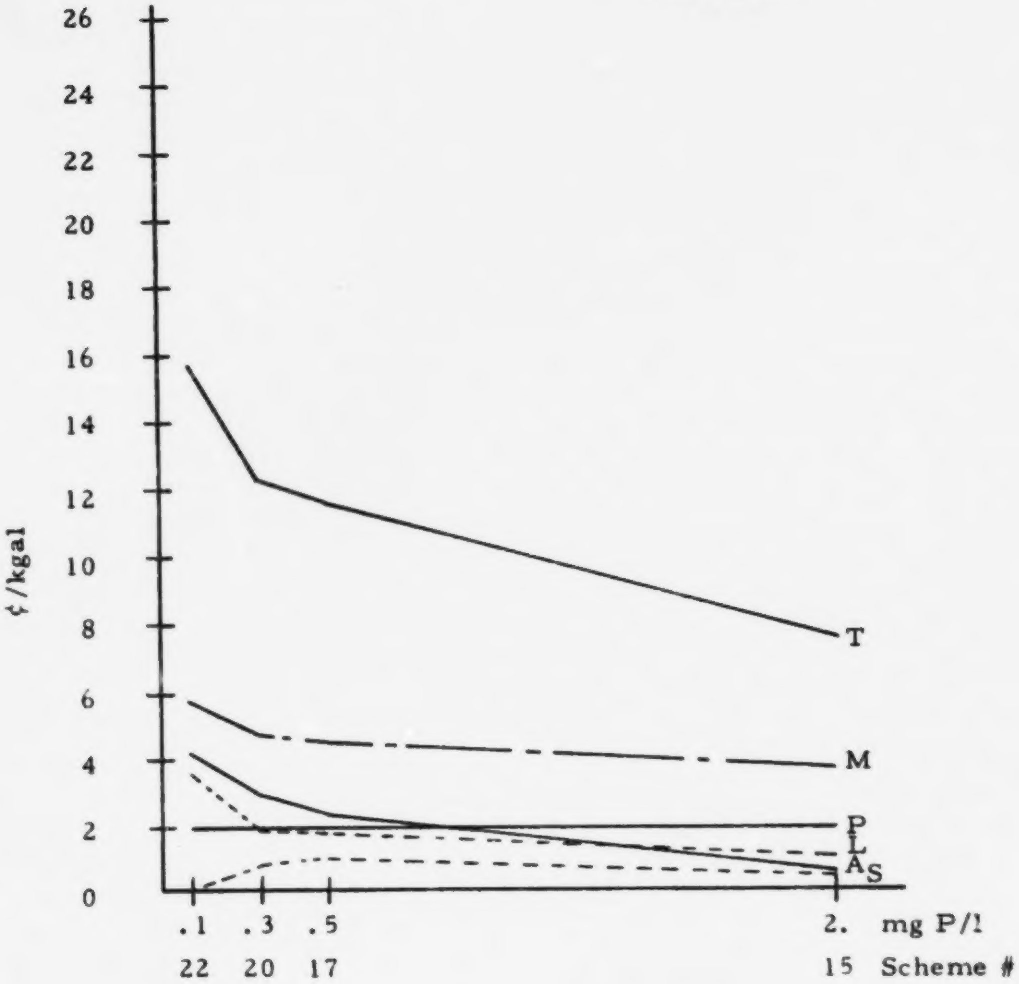


DTRGUS - 16. lb/capita/yr = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

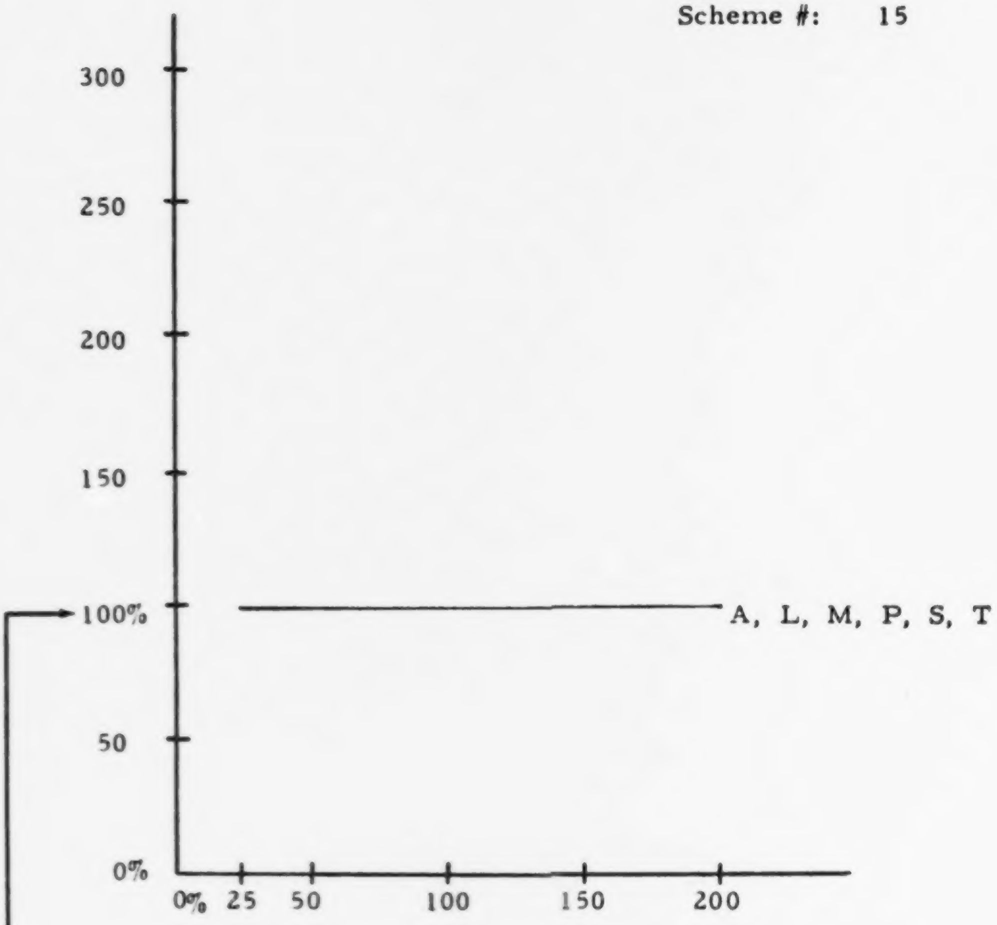
	A	L	M	P	S	T
Sensitivity at base point	-.1	-.1	-.4	+.4	-.4	-.1
Slope over the range	-.1	-.1	-.4	+.4	-.4	-.1

Symbol:	ELIMIT
Description:	Effluent Limit
Base Case:	3



A = Unit Amortization Cost
L = Unit Labor Cost
M = Unit Material & Supply Cost
P = Unit Detergent Limitation Cost
S = Unit Solid Sink Cost
T = Unit Total Cost

Symbol: ELECOS
Description: Electricity Cost
Base Case: 3
Scheme #: 15

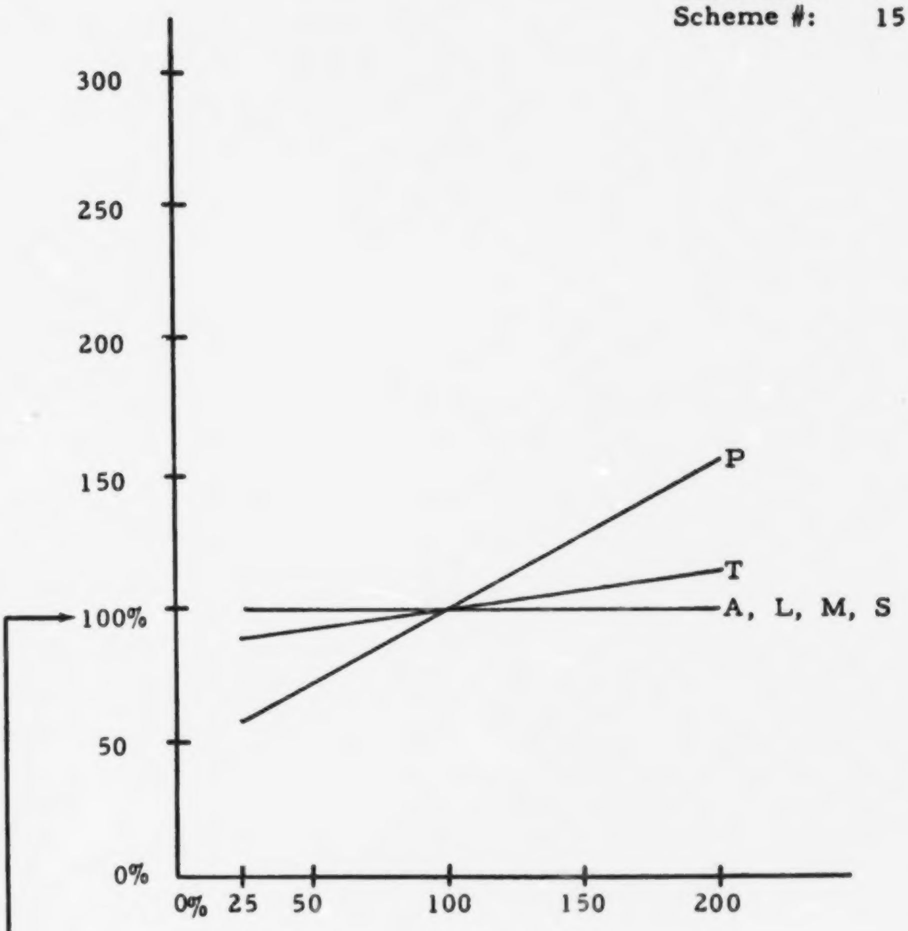


ELECOS - .01 $/KWHR = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = [illegible]00%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	0	0
Slope over the range	0	0	0	0	0	0

Symbol: ENFCST
Description: Enforcement Cost
Base Case: 3
Scheme #: 15

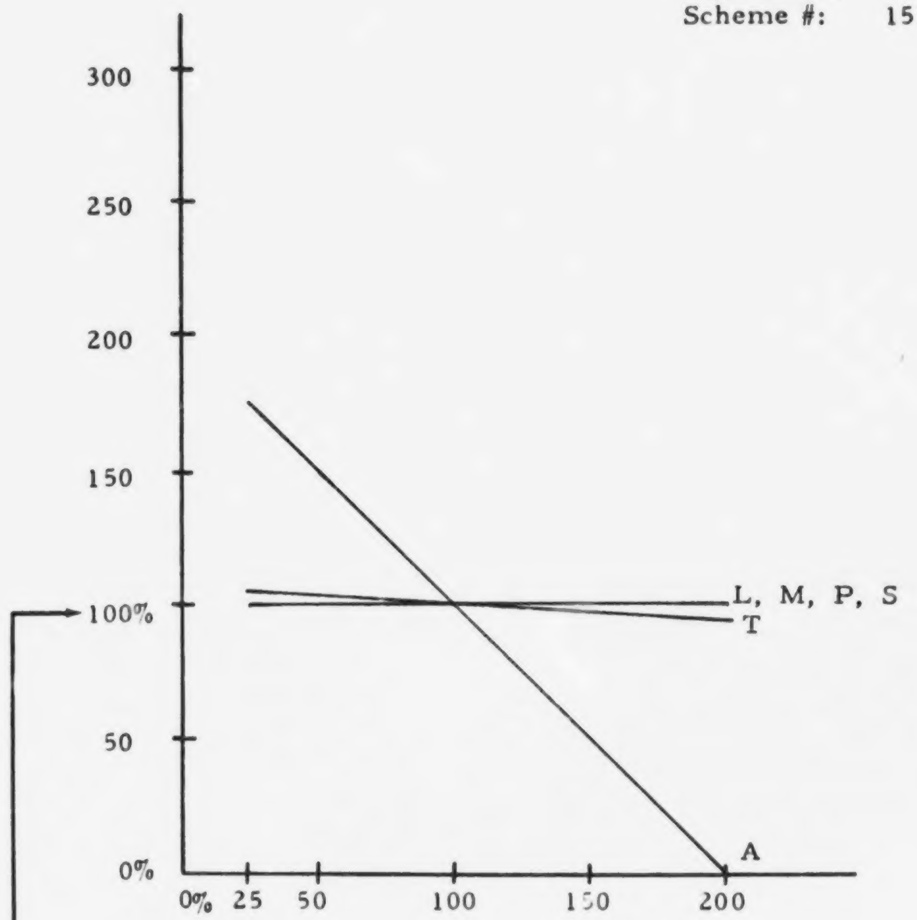


ENFCST - .4 $/capita/yr = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.6	0	.15
Slope over the range	0	0	0	.6	0	.15

Symbol: GOVFF
Description: Government Financing
Base Case: 3
Scheme #: 15

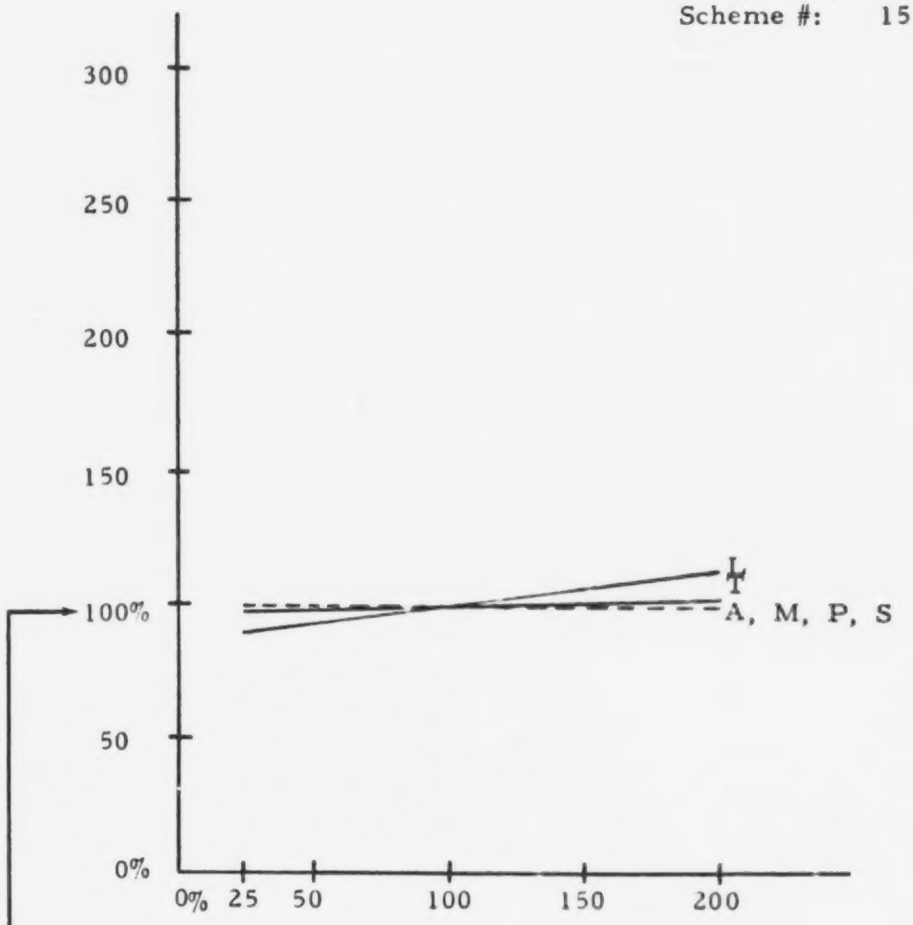


GOVFF - .5 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-1.	0	0	0	0	-.06
Slope over the range	-1.	0	0	0	0	-.06

Symbol: IDFRAC
Description: Indirect Labor
Base Case: 3
Scheme #: 15

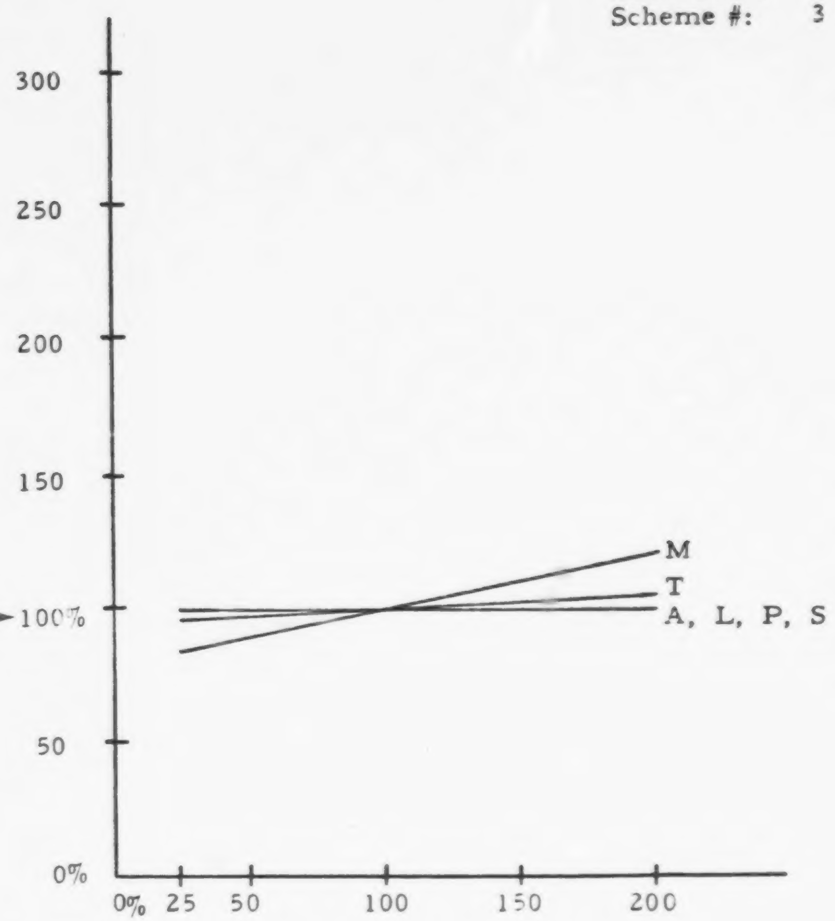


IDFRAC - .15 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.1	0	0	0	.03
Slope over the range	0	.1	0	0	0	.03

Symbol: LIMECS
Description: Lime Cost
Base Case: 3
Scheme #: 3

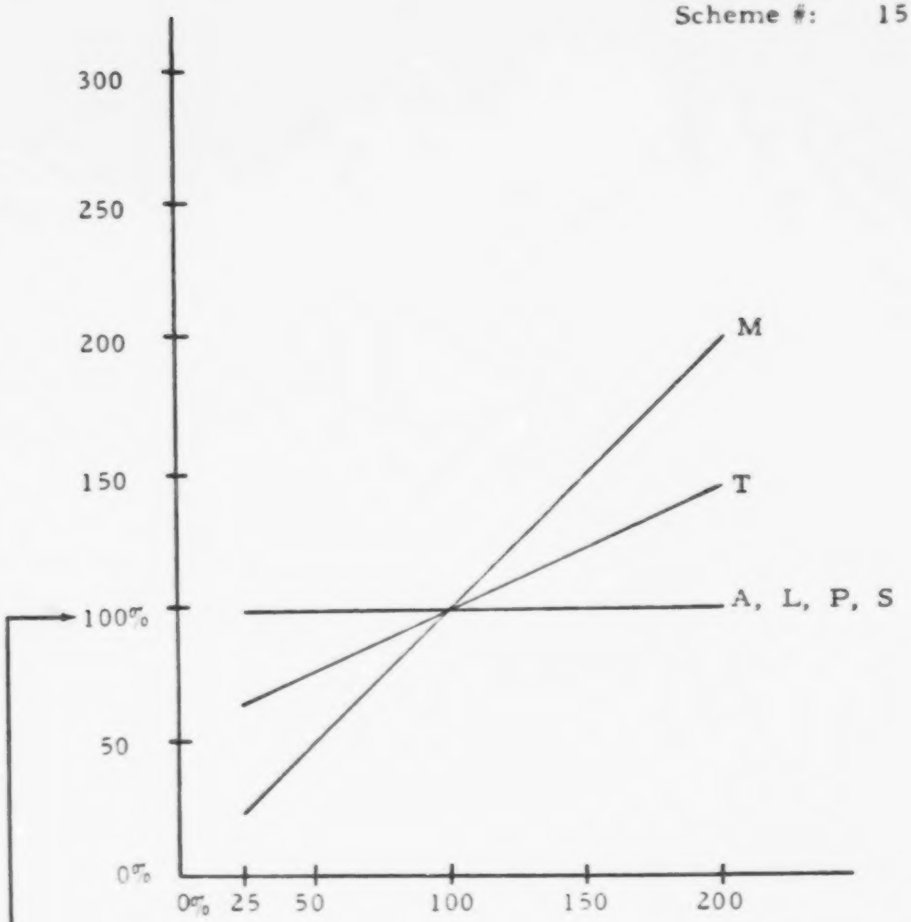


LIMECS - .01 $/LB = 100%

A = Unit Amortization Cost - 1.8 ¢/kgal = 100%
L = Unit Labor Cost - 2.9 ¢/kgal = 100%
M = Unit Material & Supply Cost - 4.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 5.6 ¢/kgal = 100%
T = Unit Total Cost - 16.9 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.2	0	0	.06
Slope over the range	0	0	.2	0	0	.06

Symbol: MATRLS
Description: Wholesale Price Index
Base Case: 3
Scheme #: 15

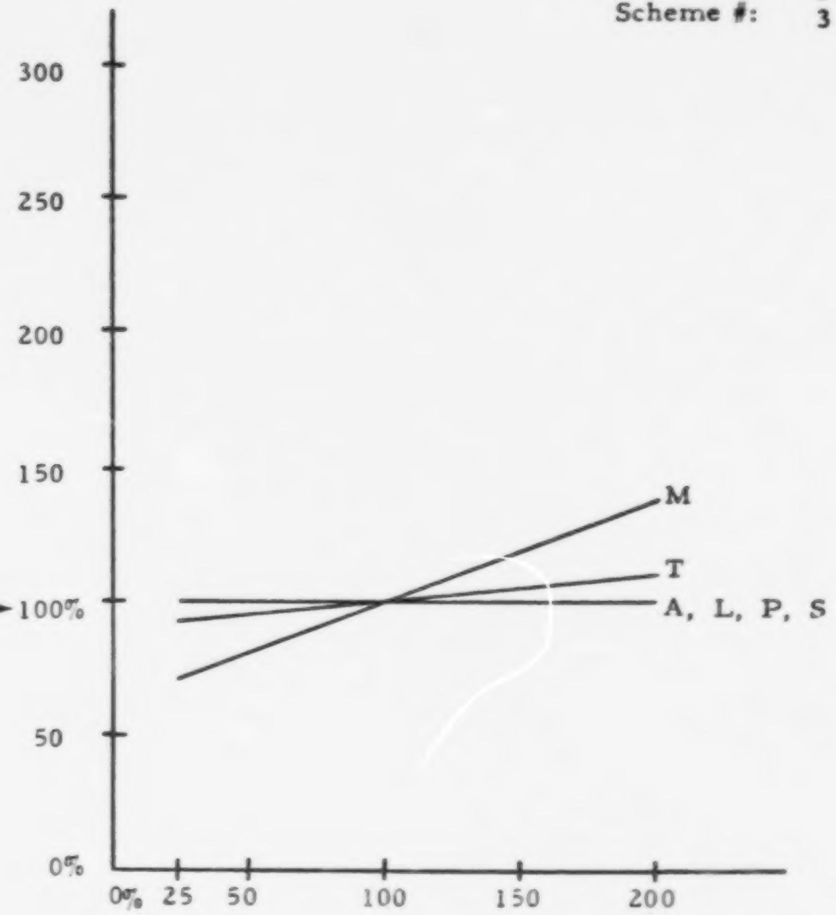


MATRLS - 1.18 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	1.	0	0	.5
Slope over the range	0	0	1.	0	0	.5

Symbol: PCKLCS
Description: Pickle Liquor Cost
Base Case: 3
Scheme #: 3

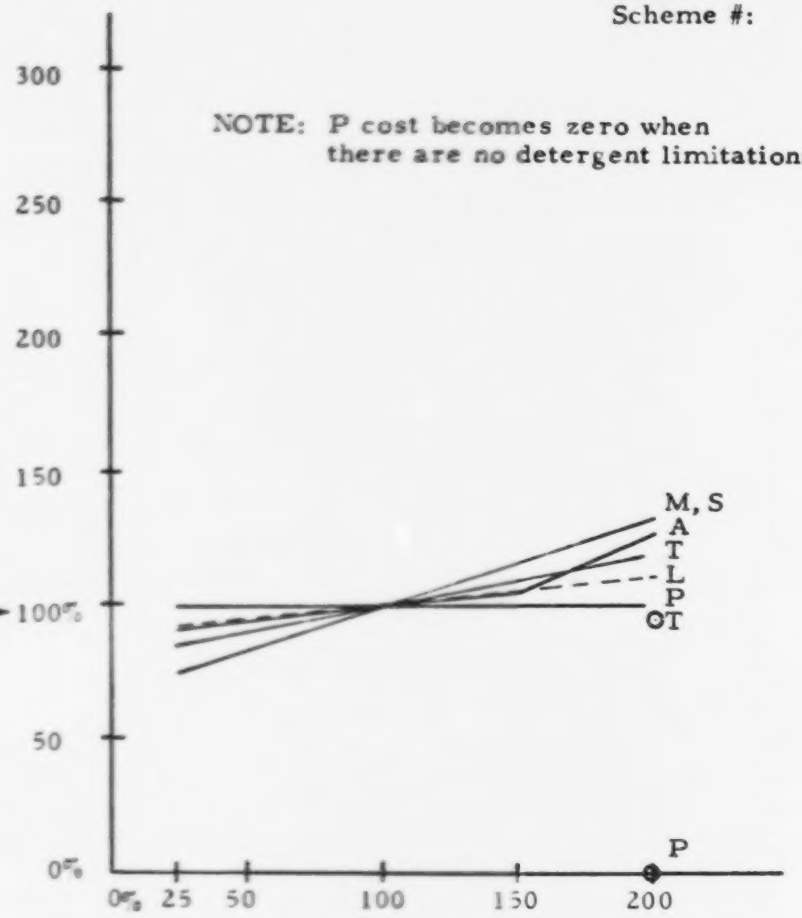


PCKLCS - .04 $/LB = 100%

A = Unit Amortization Cost - 1.8 ¢/kgal = 100%
L = Unit Labor Cost - 2.9 ¢/kgal = 100%
M = Unit Material & Supply Cost - 4.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 5.6 ¢/kgal = 100%
T = Unit Total Cost - 16.9 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.4	0	0	.1
Slope over the range	0	0	.4	0	0	.1

Symbol: PCNTNT
Description: Detergent Phosphorus
Base Case: 3
Scheme #: 15



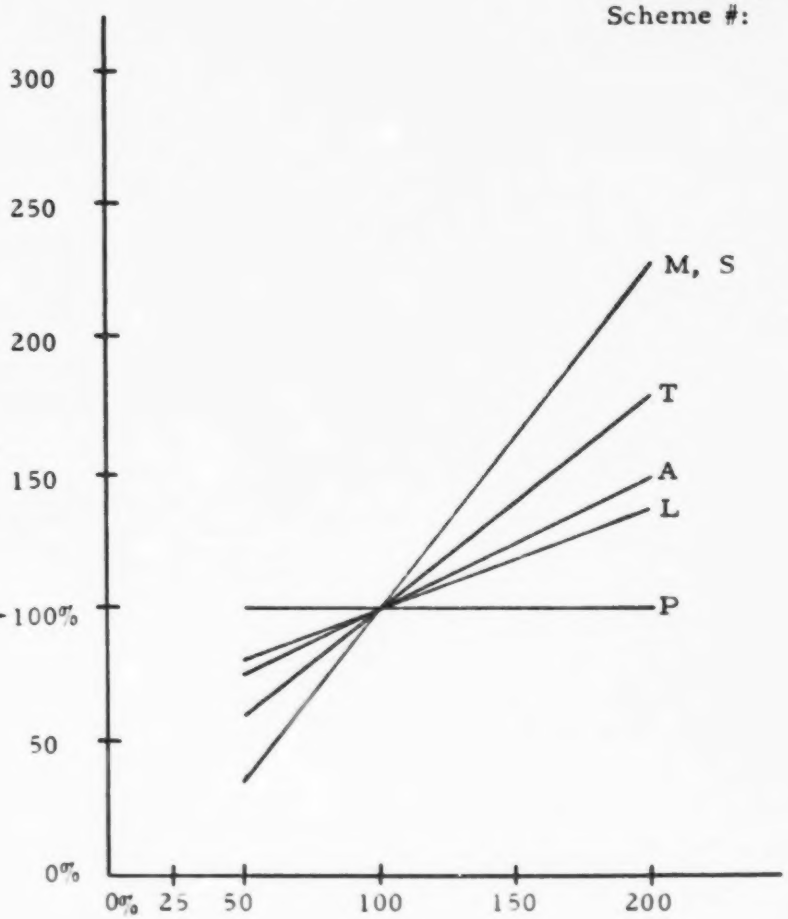
NOTE: P cost becomes zero when there are no detergent limitations

PCNTNT - .05 = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.2	.1	.4	0	.4	.2
Slope over the range	.2	.1	.4	0	.4	.2

Symbol: PINPS
Description: Influent Phosphorus
Base Case: 3
Scheme #: 15

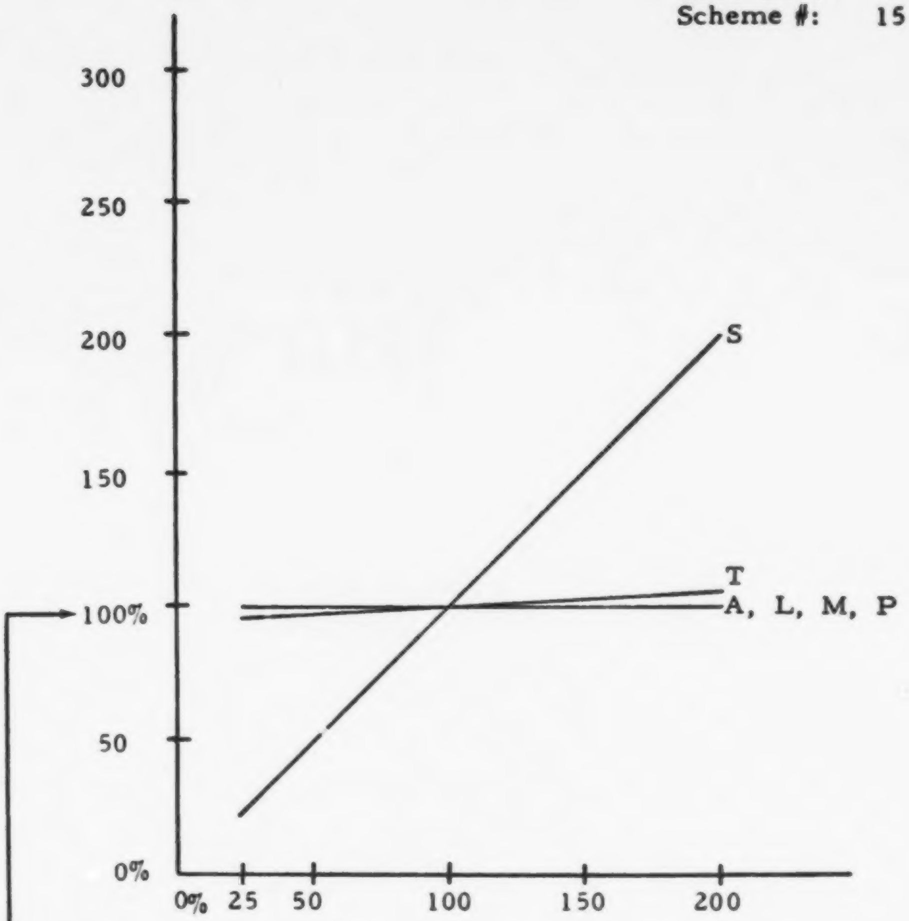


PINPS - 10 mg P/l = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.5	.4	1.3	0	1.3	.8
Slope over the range	.5	.4	1.3	0	1.3	.8

Symbol: TRNCST
Description: Transportation Cost
Base Case: 3
Scheme #: 15



TRNCST - 5. $/TON-MILE = 100%

A = Unit Amortization Cost - 0.5 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.6 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 2.0 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.4 ¢/kgal = 100%
T = Unit Total Cost - 7.5 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	1.	.06
Slope over the range	0	0	0	0	1.	.06

CASE 4 - BROCKTON, MASS.

Conclusions

The parameter with greatest effect on the unit costs of treatment was ELIMIT, the phosphorus effluent level. As the effluent level was decreased from 2.0 mg P/l to 0.1 mg P/l the cost of removal went from 6.7¢/kgal to 13.3¢/kgal, an increase in cost of 100%. The next most important parameter was PINPS, the influent phosphorus level. As it was changed from 25% to 200% of its base value of 15. mg P/l, the cost of removal for the least costly scheme changed from 49% to 174% of its base value of 6.7¢/kgal. Changing ALUMCS, the cost of alum, from 25% to 200% of its base value of 3¢/lb caused the total treatment cost to go from 56% to 159% of its base value of 11.4¢/kgal. MATRLS, the Wholesale Price Index, was next in influence causing costs to go from 58% to 156% as it went from 25% to 200% of its base value of May 72. Table 6 contains those parameters which caused one or more sub-measures (costs) to have a sensitivity ≥ 1.41 ranked by the sensitivity of T, the total cost. Following this are the sensitivity graphs of all of the parameters.

Description

The treatment plant at Brockton, Mass., is a 12 MGD activated sludge plant. The sludge is thickened by air flotation, vacuumed filtered and then disposed of next to the plant. A complete listing of the input variables and values to the program SARMVE is contained in the appendices along with the plant survey results.

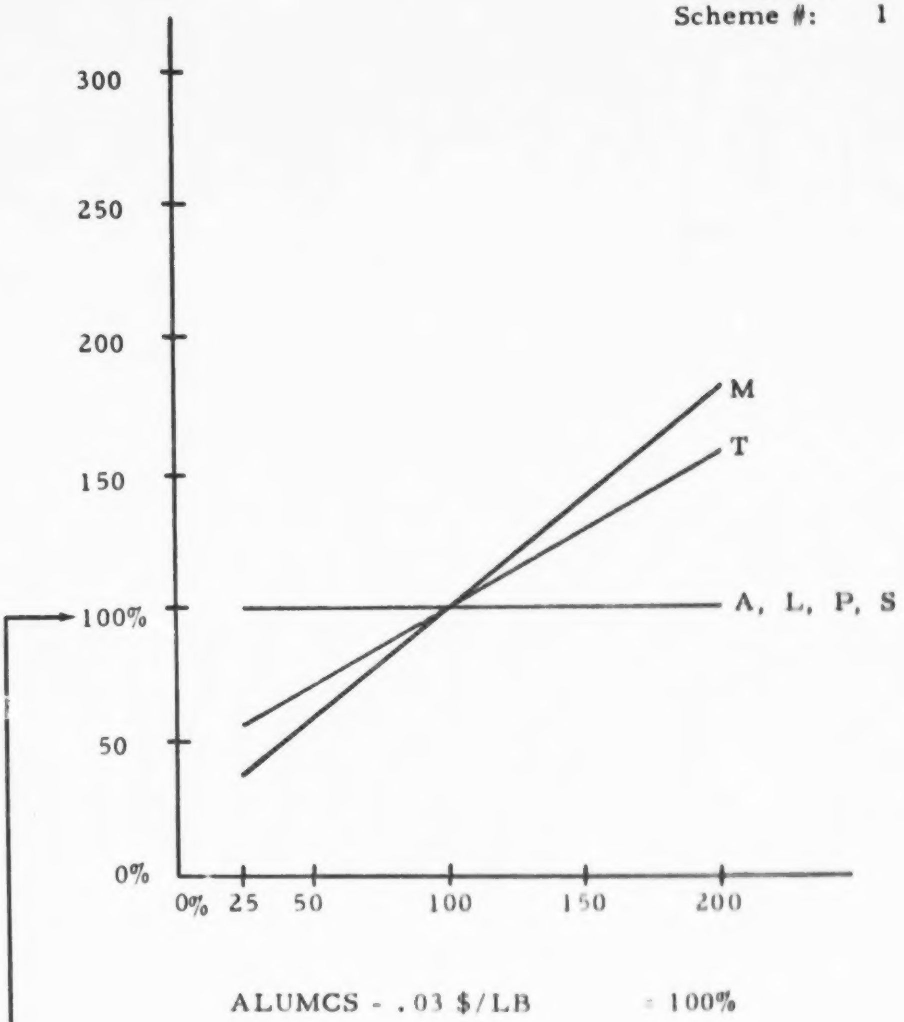
TABLE 6

Sensitivity Ranking - Case 4

	MEASURES					
PARAMETER	T	A	L	M	P	S
ELIMIT	*					
PINPS	.7	.65	.6	1.1		
ALUMCS	.6			.8		
MATRLS	.6			1.		
PCKLCS	.24			.4		
DIFCOS	.2				.6	
ENFCST	.12				.4	
DHR	.1		1.			
AMLIFE	-.05	-1.2				
CNSTRC	.04	1.				
GOVFF	-.04	-1.				
AMRATE	.02	.4				

*The sensitivity of ELIMIT is not computed on the basis of a percentage change.

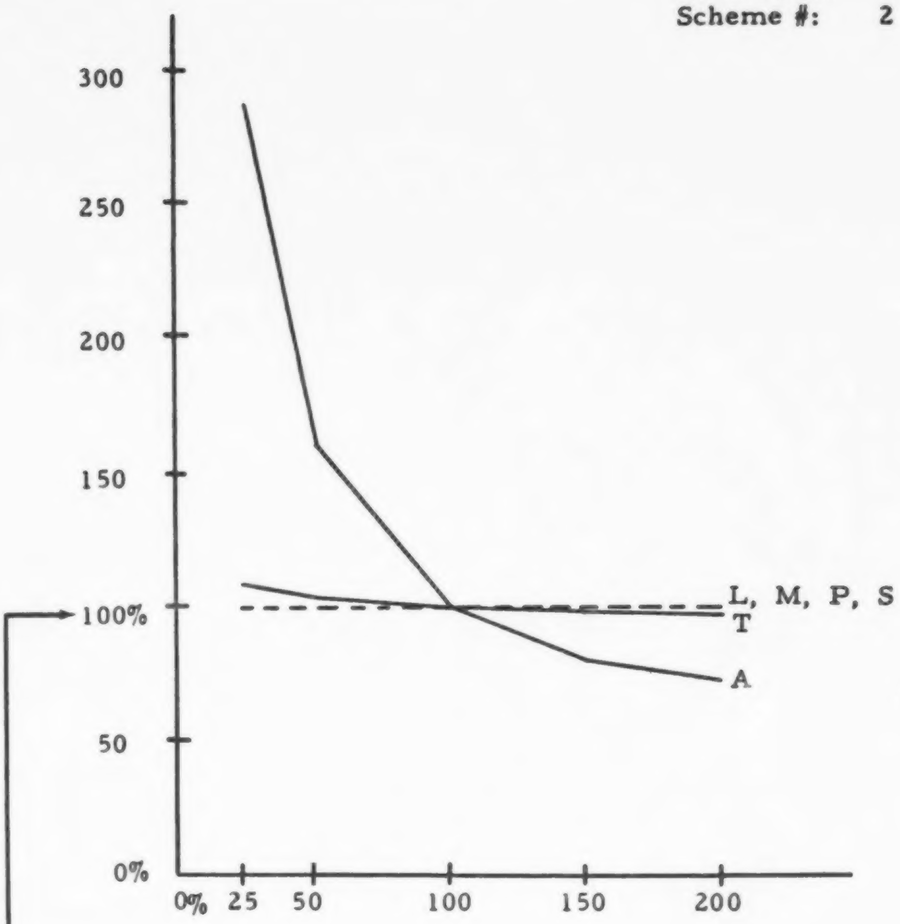
Symbol: ALUMCS
Description: Alum Cost
Base Case: 4
Scheme #: 1



A = Unit Amortization Cost - 0.4 ¢/kgal = 100%
L = Unit Labor Cost - 1.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 8.0 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 11.4 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.8	0	0	.6
Slope over the range	0	0	.8	0	0	.6

Symbol: AMLIFE
Description: Amortization Life
Base Case: 4
Scheme #: 2

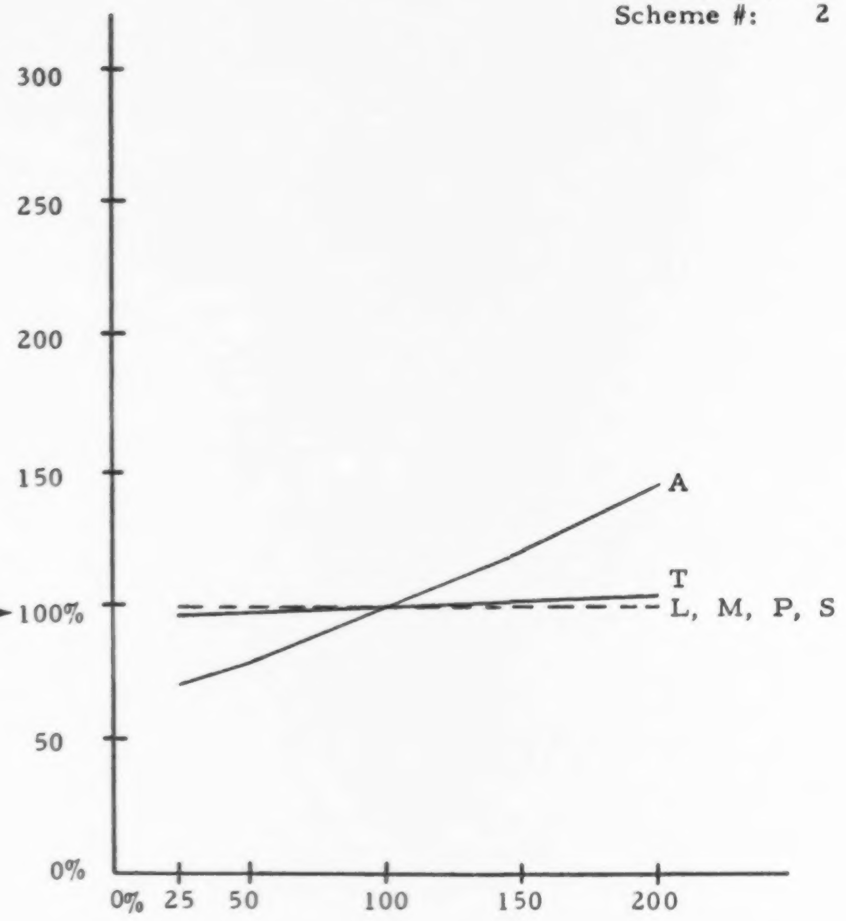


AMLIFE - 20 YEARS = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-.8	0	0	0	0	-.05
Slope over the range	-1.2	0	0	0	0	-.05

Symbol: AMRATE
Description: Amortization Rate
Base Case: 4
Scheme #: 2

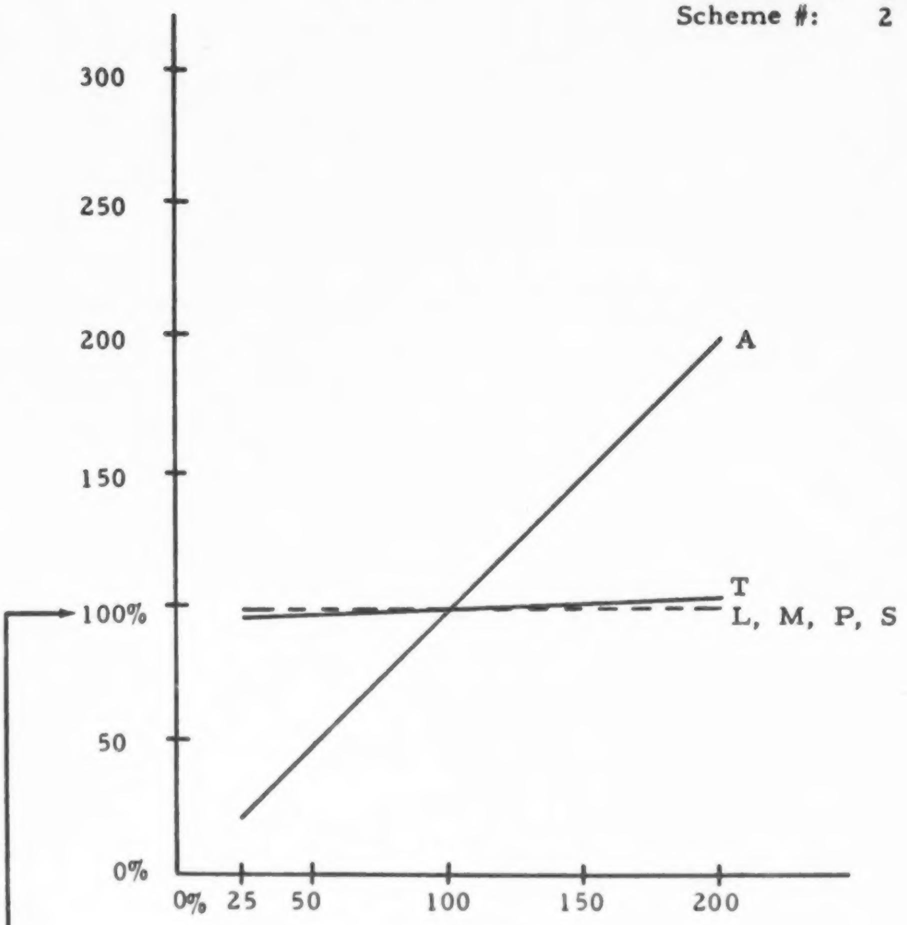


AMRATE - .05 = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.4	0	0	0	0	.02
Slope over the range	.4	0	0	0	0	.02

Symbol: CNSTRC
Description: WQO-STP Index
Base Case: 4
Scheme #: 2

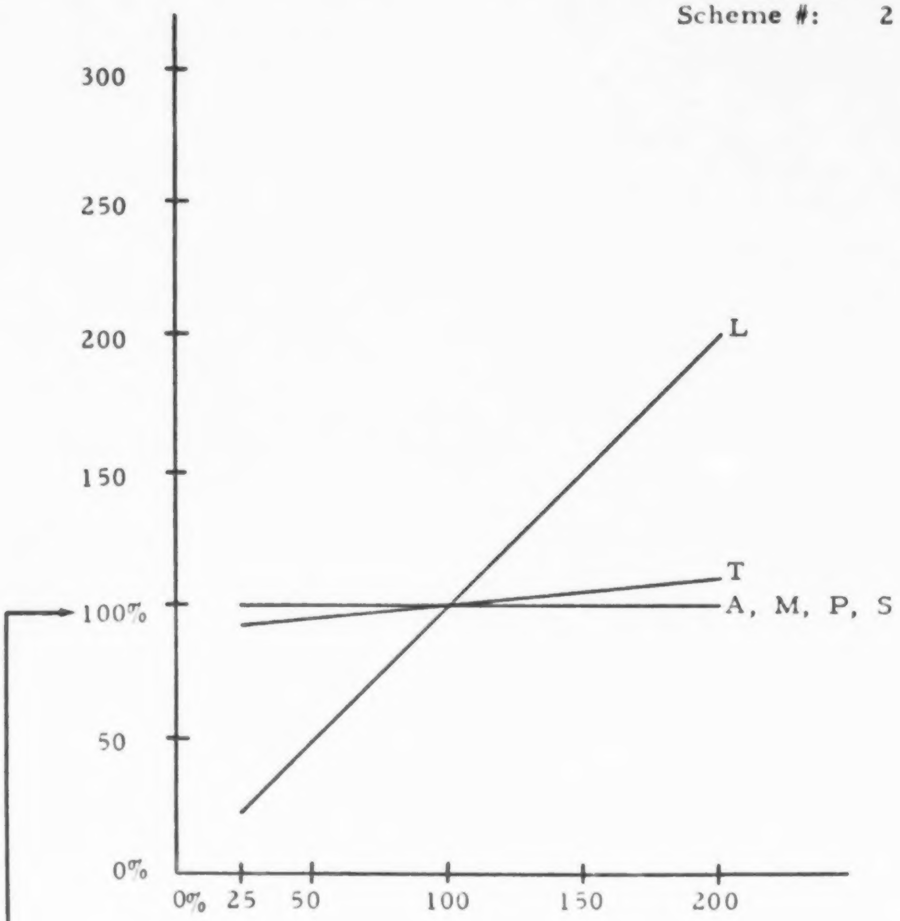


CNSTRC - 1.71 = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	1.	0	0	0	0	.04
Slope over the range	1.	0	0	0	0	.04

Symbol: DHR
Description: Labor Rate
Base Case: 4
Scheme #: 2

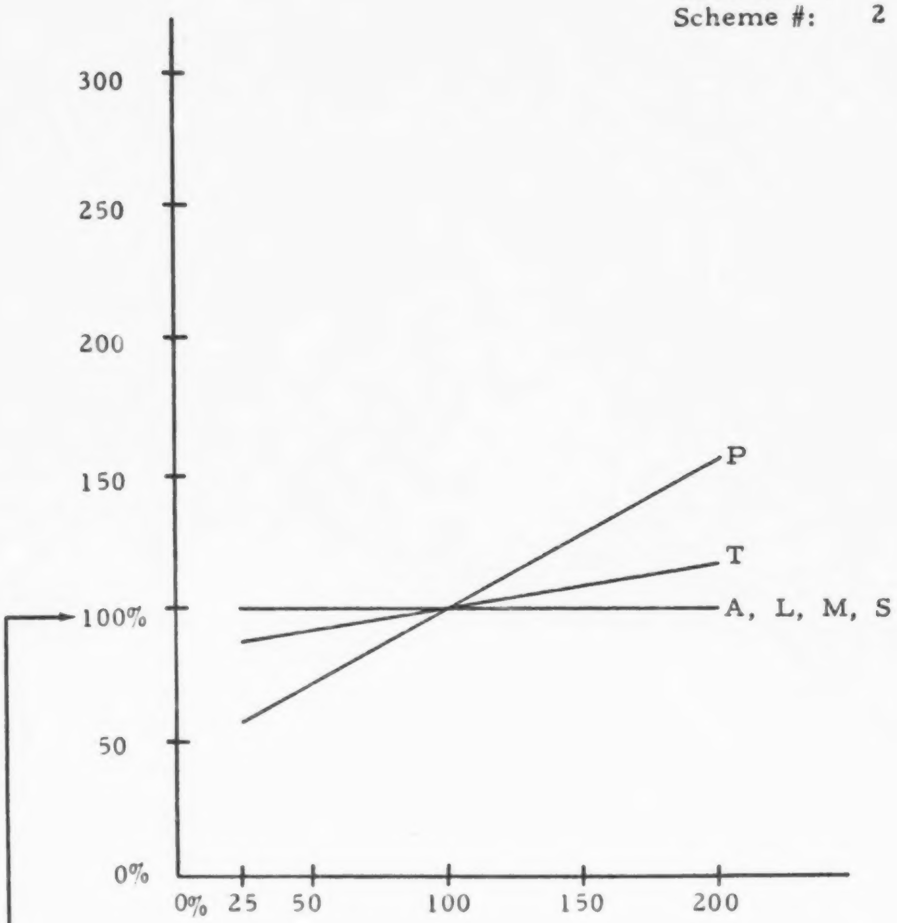


DHR - 4.00 $ /HOUR = 100%

A = Unit Amortization Cost - 0.4 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	1.	0	0	0	.1
Slope over the range	0	1.	0	0	0	.1

Symbol:	DIFCOS
Description:	Detergent Cost
Base Case:	4
Scheme #:	2

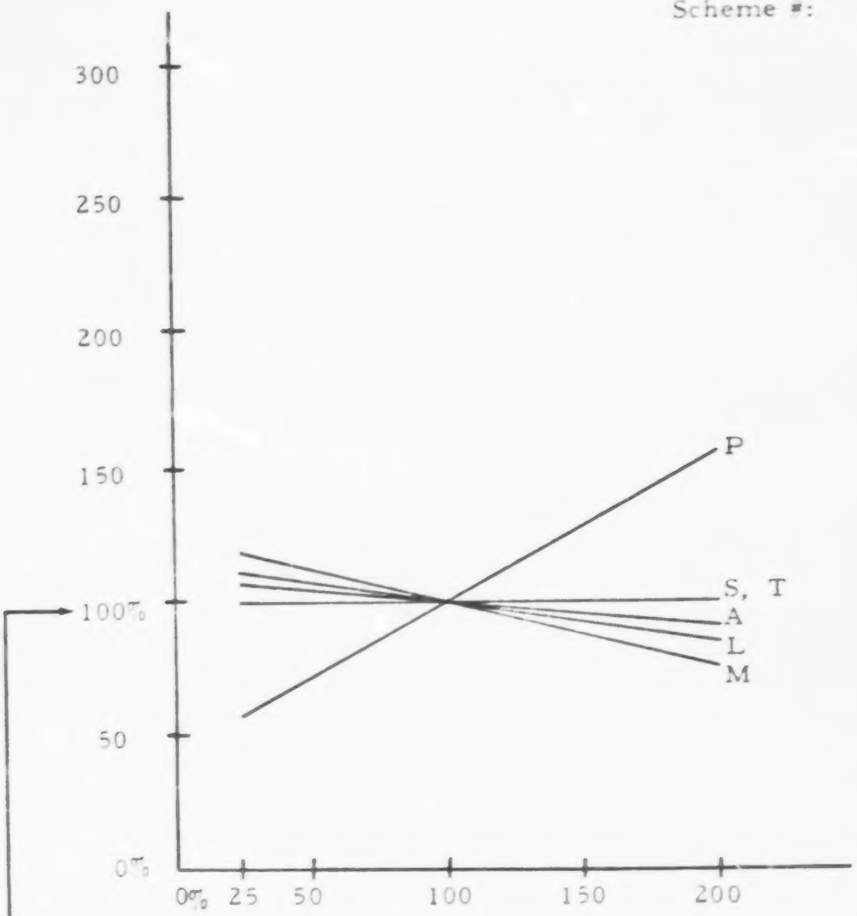


DIFCOS - .02 $/LB = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.6	0	2
Slope over the range	0	0	0	.6	0	.2

Symbol: DTRGUS
Description: Detergent Use
Base Case: 4
Scheme #: 2

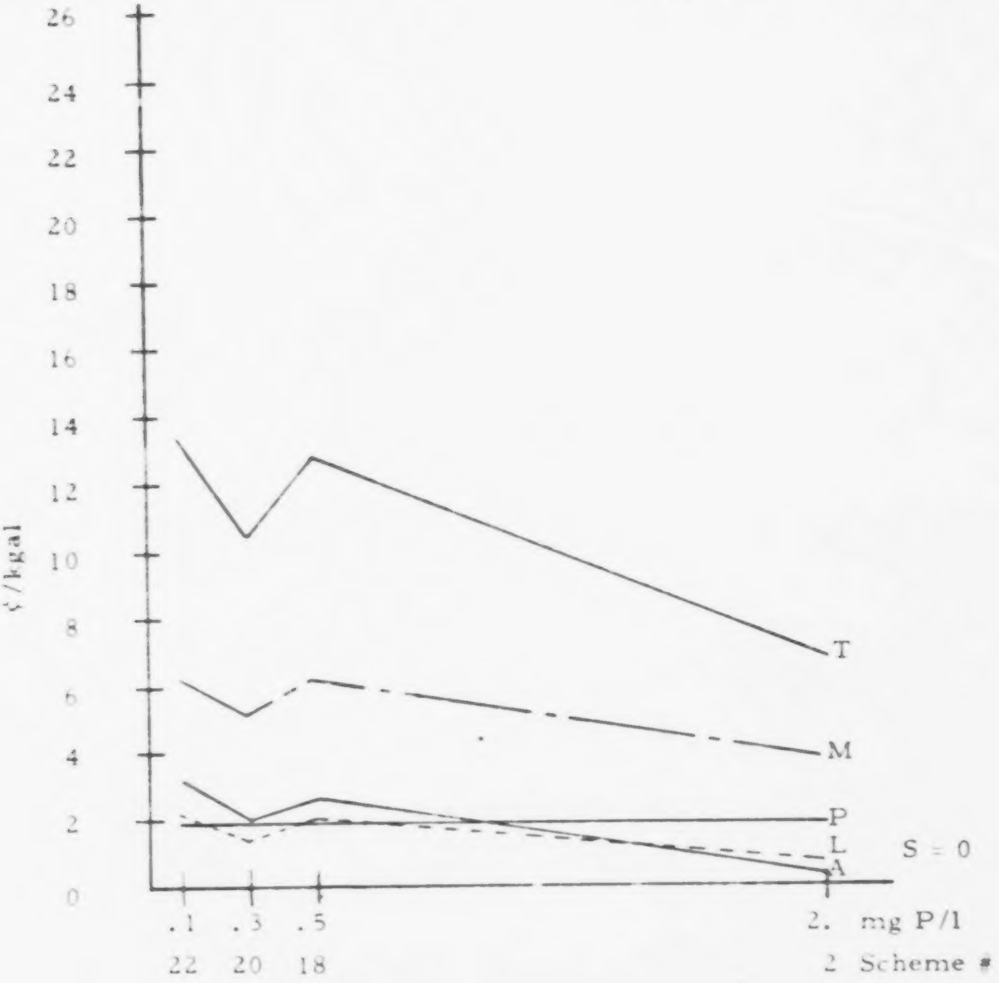


DTRGUS - 27 lb/capita/yr = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

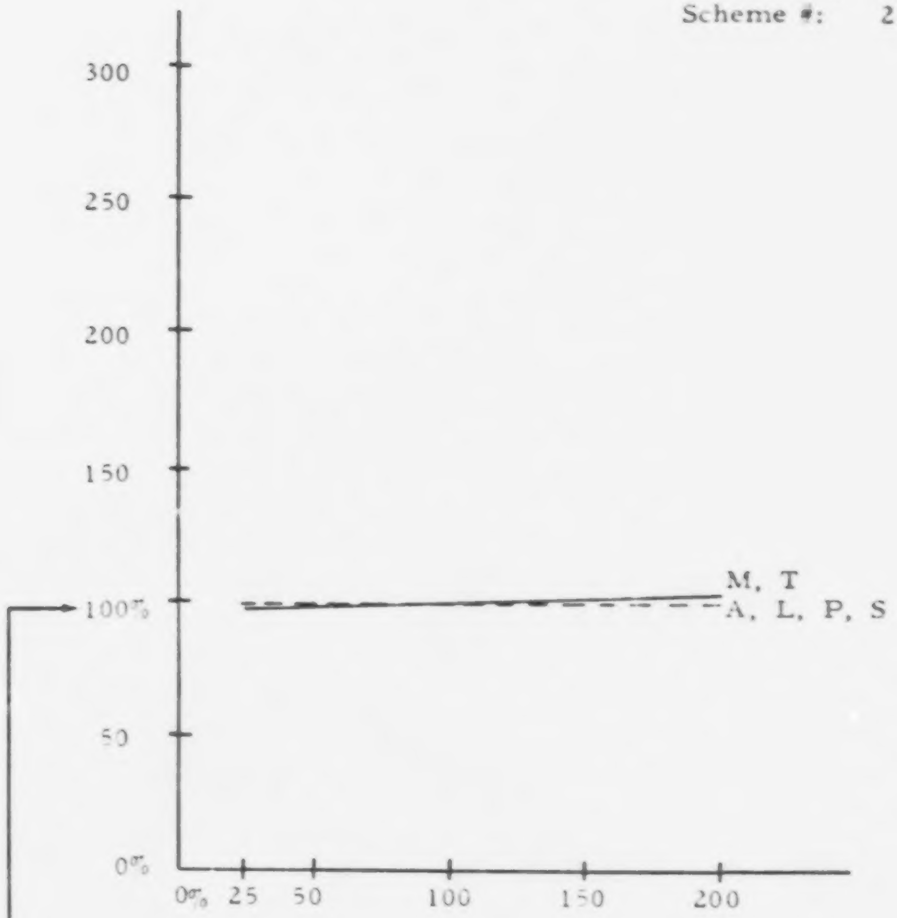
	A	L	M	P	S	T
Sensitivity at base point	-.09	-.14	-.25	.6	0	0
Slope over the range	-.09	-.14	-.25	.6	0	0

Symbol: ELIMIT
Description: Effluent Limit
Base Case: 4



A = Unit Amortization Cost
L = Unit Labor Cost
M = Unit Material & Supply Cost
P = Unit Detergent Limitation Cost
S = Unit Solid Sink Cost
T = Unit Total Cost

Symbol: ELECOS
Description: Electricity Cost
Base Case: 4
Scheme #: 2

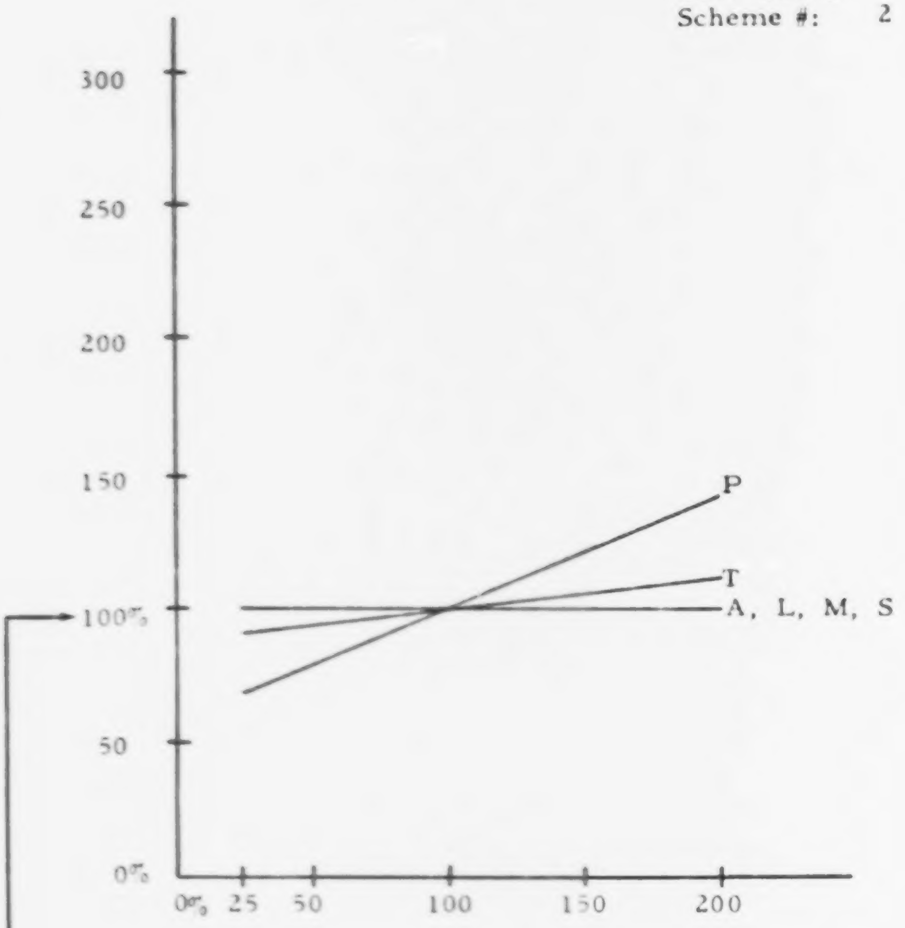


ELECOS - .0175 $/KWHR = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.03	0	0	.02
Slope over the range	0	0	.03	0	0	.02

Symbol: ENFCST
Description: Enforcement Cost
Base Case: 4
Scheme #: 2

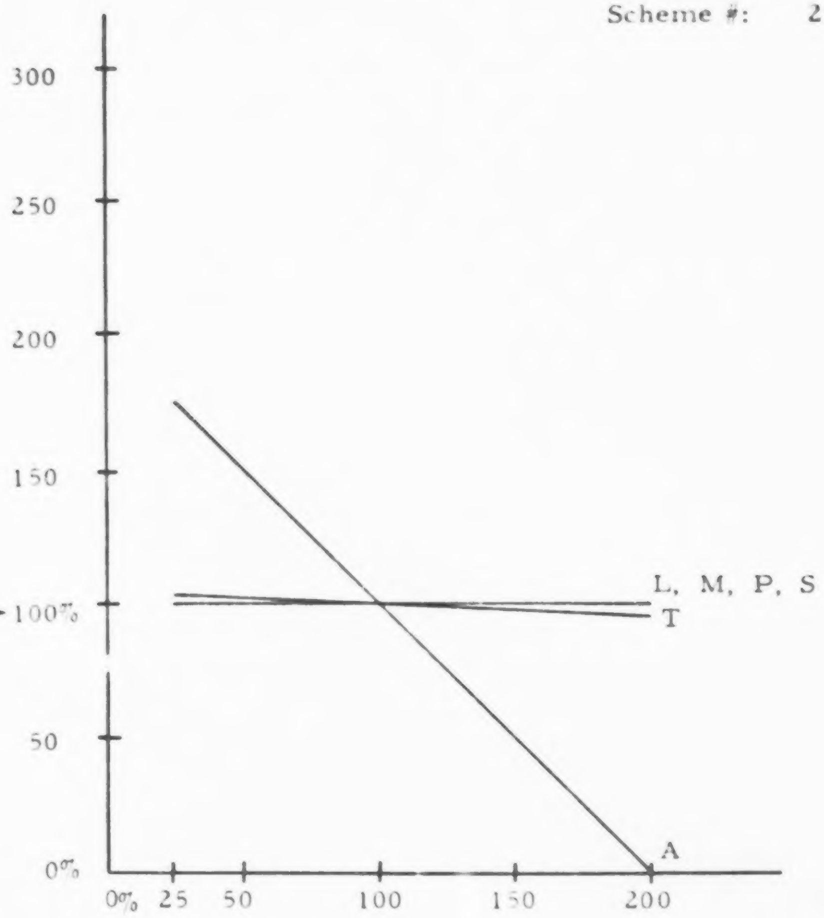


ENFCST - .4 $/capita/yr = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.4	0	.12
Slope over the range	0	0	0	.4	0	.12

Symbol: GOVFF
Description: Government Financing
Base Case: 4
Scheme #: 2

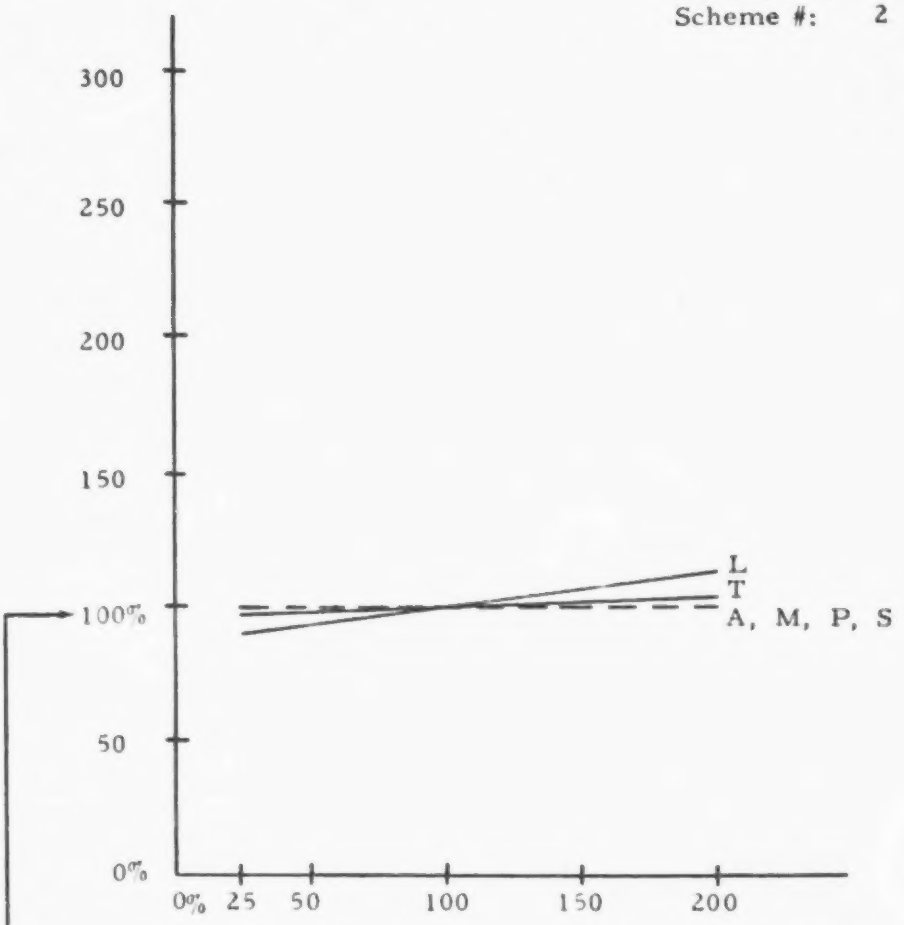


GOVFF - .5 = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-1.	0	0	0	0	-.04
Slope over the range	-1.	0	0	0	0	-.04

Symbol: IDFRAC
Description: Indirect Labor
Base Case: 4
Scheme #: 2

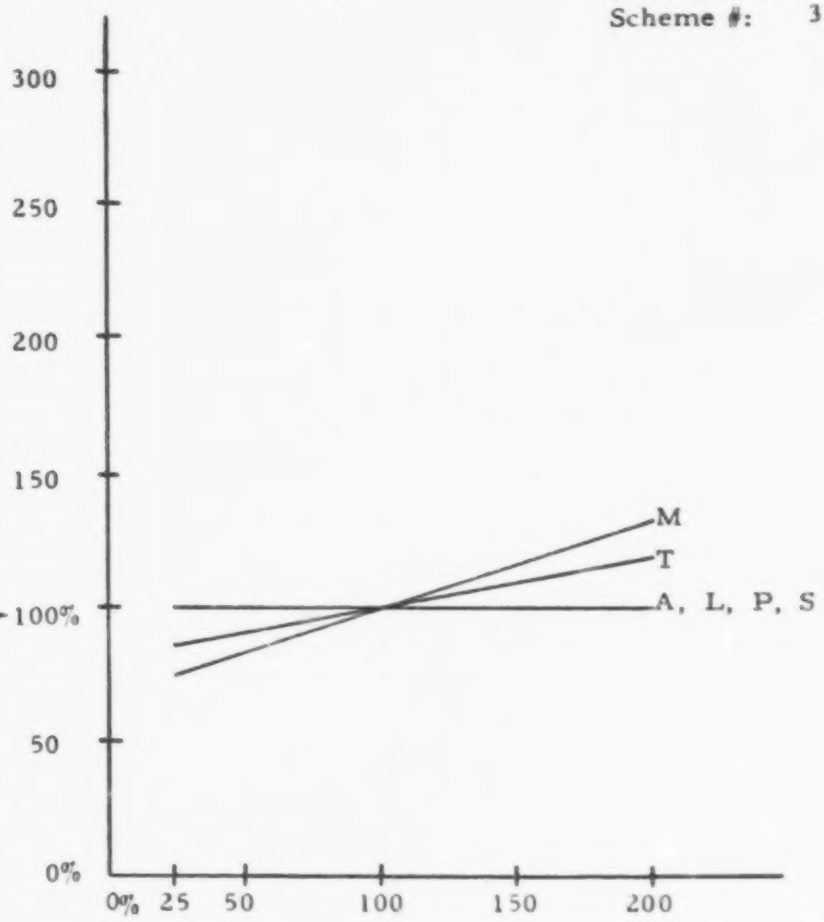


IDFRAC - .15 = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.13	0	0	0	.01
Slope over the range	0	.13	0	0	0	.01

Symbol: LIMECS
Description: Lime Cost
Base Case: 4
Scheme #: 3

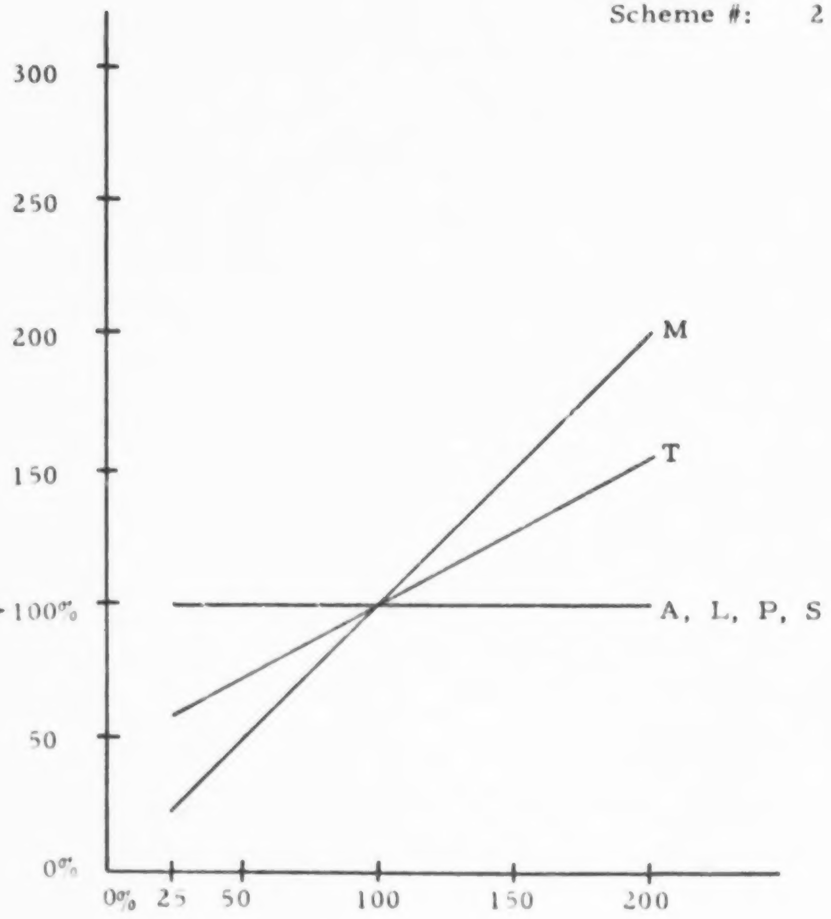


LIMECS - .02 $/LB = 100%

A = Unit Amortization Cost - 1.0 ¢/kgal = 100%
L = Unit Labor Cost - 2.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 6.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 11.8 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.3	0	0	.2
Slope over the range	0	0	.3	0	0	.2

Symbol: MATRLS
Description: Wholesale Price Index
Base Case: 4
Scheme #: 2

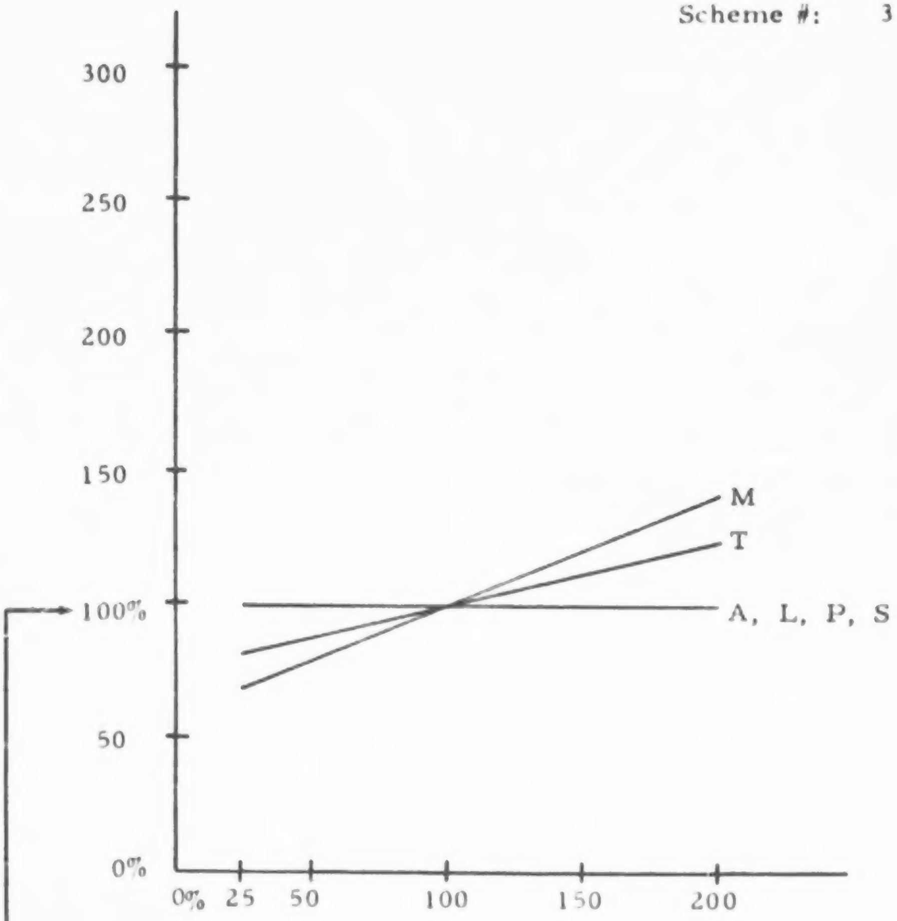


MATRLS - 1.18 = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	1.	0	0	.6
Slope over the range	0	0	1.	0	0	.6

Symbol: PCKLCS
Description: Pickle Liquor Cost
Base Case: 4
Scheme #: 3

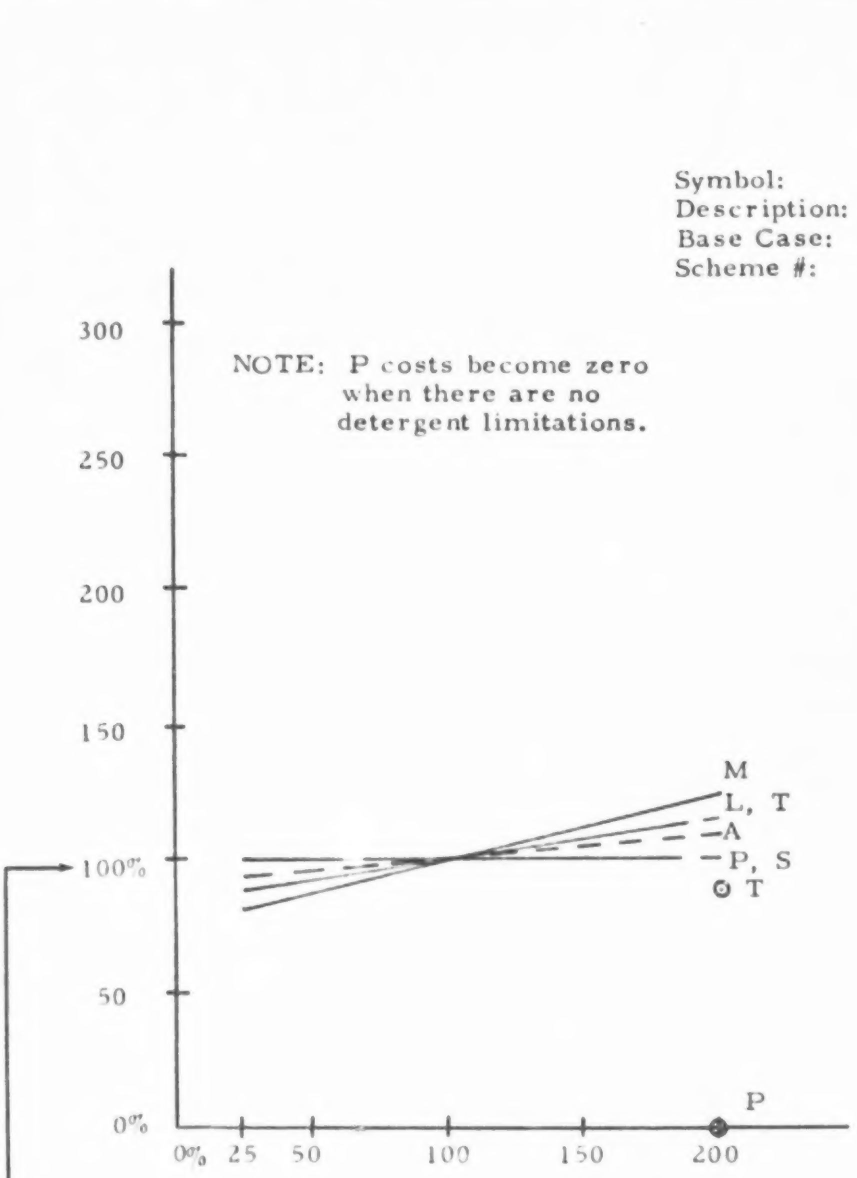


PCKLCS - 0.4 $/LB = 100%

A = Unit Amortization Cost - 1.0 ¢/kgal = 100%
L = Unit Labor Cost - 2.0 ¢/kgal = 100%
M = Unit Material & Supply Cost - 6.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 11.8 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.4	0	0	.24
Slope over the range	0	0	.4	0	0	.24

Symbol: PCNTNT
Description: Detergent Phosphorus
Base Case: 4
Scheme #: 2



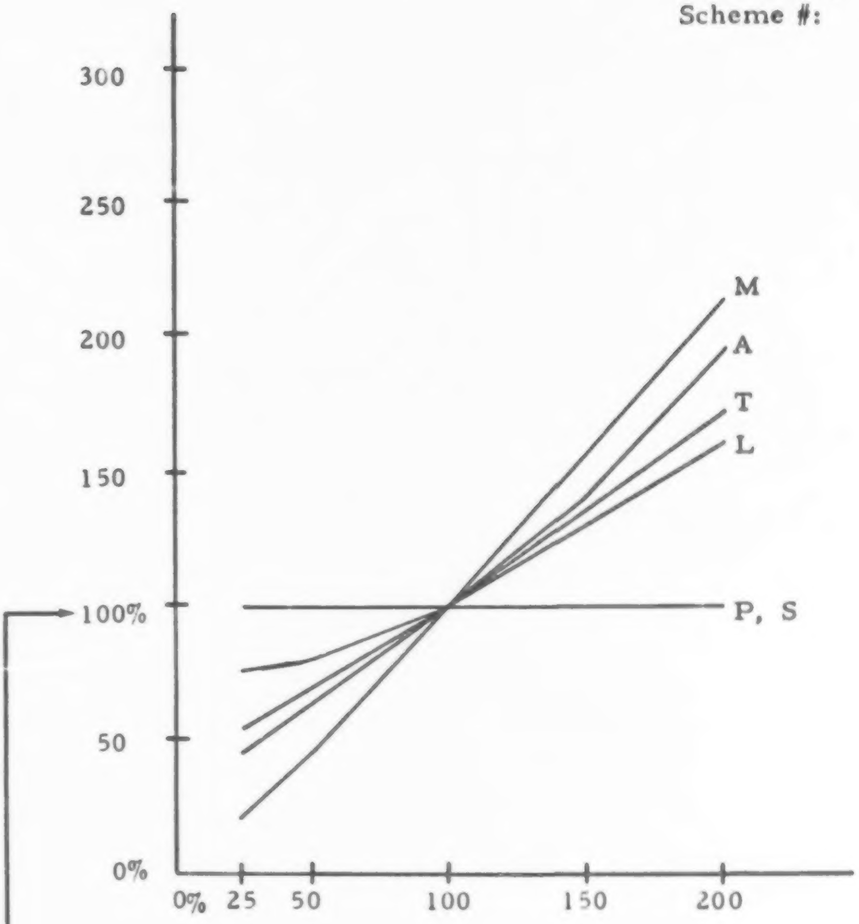
NOTE: P costs become zero when there are no detergent limitations.

PCNTNT - 0.5 = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.09	.15	.25	0	0	.15
Slope over the range	.09	.15	.25	0	0	.15

Symbol: PINPS
Description: Influent Phosphorus
Base Case: 4
Scheme #: 2

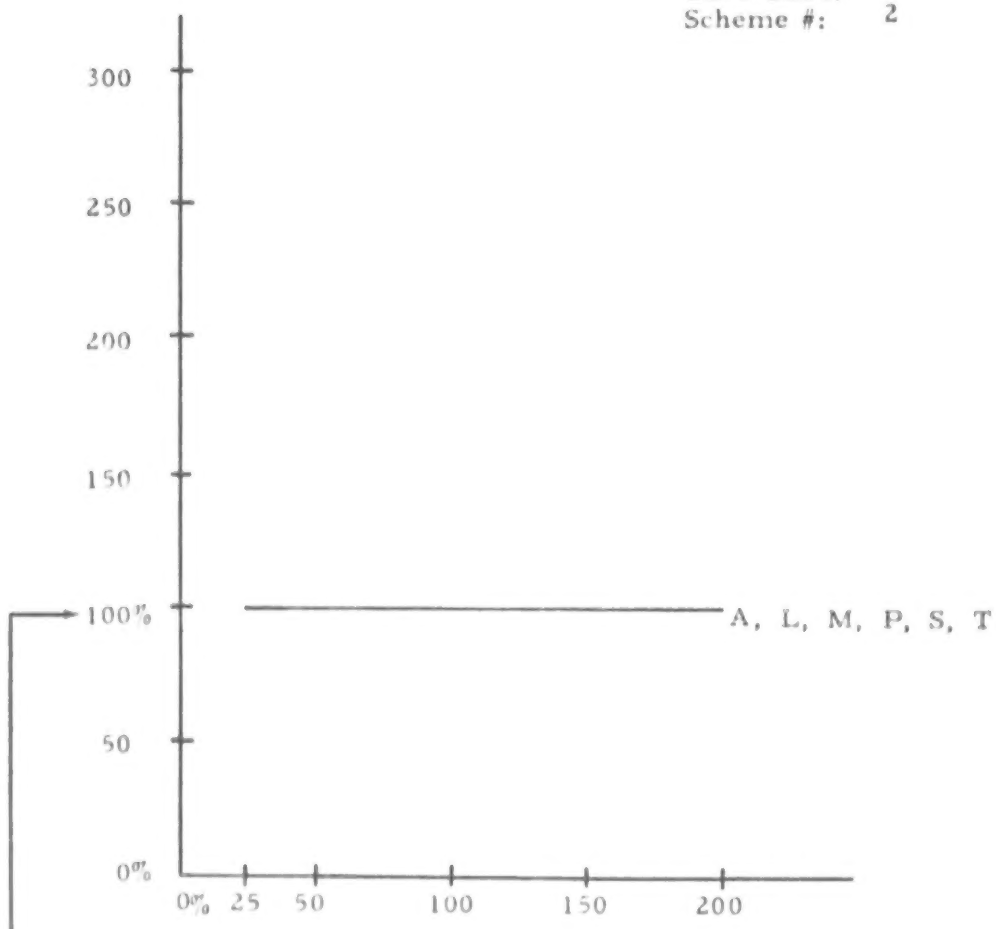


PINPS - 15. mg P/l = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.65	.6	1.1	0	0	.7
Slope over the range	.65	.6	1.1	0	0	.7

Symbol: TRNCST
Description: Transportation Cost
Base Case: 4
Scheme #: 2



TRNCST - 0.0 $/ton-mile = 100%

A = Unit Amortization Cost - 0.3 ¢/kgal = 100%
L = Unit Labor Cost - 0.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 3.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 1.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	0	0
Slope over the range	0	0	0	0	0	0

CASE 5 - PROVIDENCE, R.I.

Conclusions

The parameter with the greatest effect on the unit costs of treatment was ELIMIT, the phosphorus effluent level. As the effluent level was decreased from 2.0 mg P/l to 0.1 mg P/l the cost of removal went from 3.6¢/kgal to 8.0¢/kgal, an increase in cost of 125%. The next most important parameter was PINPS, the influent phosphorus level. As it was changed from 25% to 200% of its base value of 10. mg P/l, the total cost of removal for the least costly scheme changed from 41% to 179% of its base value of 3.6¢/kgal. Changing ALUMCS, the cost of alum, from 25% to 200% of its base value of 3¢/lb caused the total treatment cost to go from 47% to 141% of its base value of 7.2¢/kgal. MATRLS, the Wholesale Price Index, was next in influence causing costs to change from 60% to 154% as it went from 25% to 200% of its base value of May 72. PCKLCS, the cost of pickle liquor, was also significant as a change in its base value of 4¢/lb from 25% to 200% caused the total cost to move from 84% to 122% of its base value of 10.0¢/kgal. Table 7 contains those parameters which caused one or more sub-measures (costs) to have sensitivity ≥ 1.41 ranked by the sensitivity of T, the total cost. Following this are the sensitivity graphs of all of the parameters.

Description

The 50 MGD activated sludge plant at Providence, R.I., uses a gravity thickener for sludge conditioning. This is followed by vacuum filtration and incineration. The ash is then taken to a landfill site 2 miles away. A complete listing of the input variables and values to the program SARMVE is contained in the appendices along with the plant survey results.

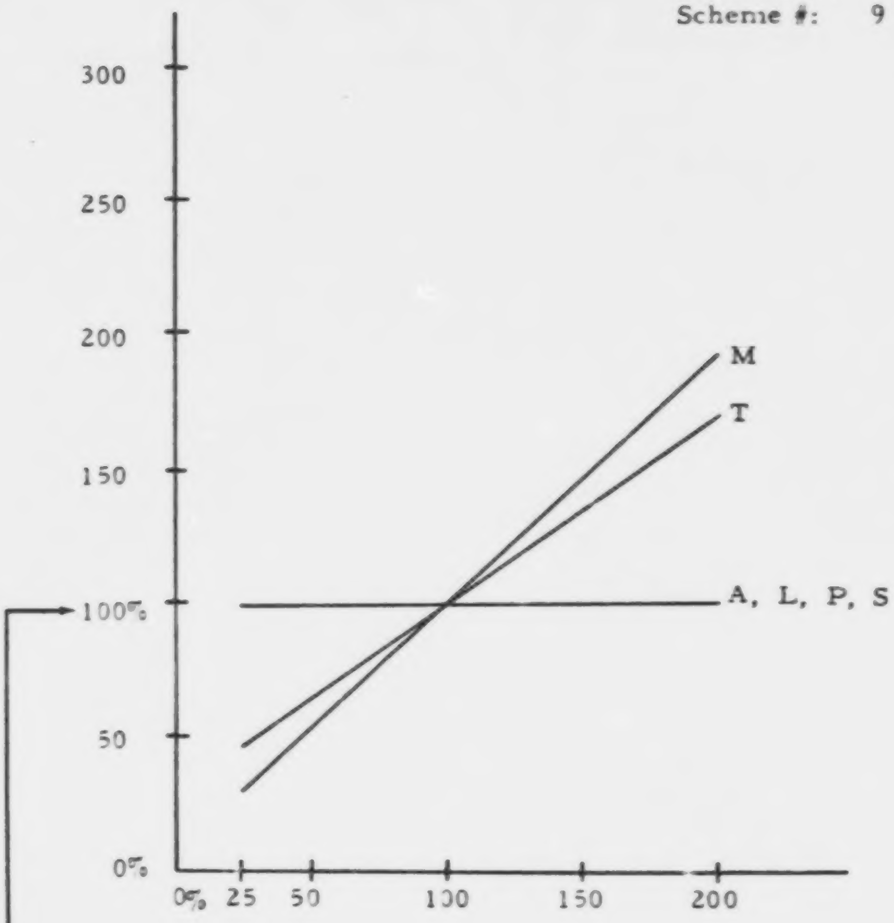
TABLE 7

Sensitivity Ranking - Case 5

	MEASURES					
PARAMETERS	T	A	L	M	P	S
ELIMIT	*					
PINPS	.8	1.3	.8	1.		1.1
ALUMCS	.7			.9		
MATRLS	.5			1.		
PCKLCS	.2			.5		
LIMECS	.15			.5		
ENFCST	.14				.6	
DHR	.1		1.			
DIFCOS	.1				.4	
TRNCST	.09					1.
AMLIFE	-.03	-1.2				
CNSTRC	.02	1.				
DTRGUS	.02				.44	
GOVFF	-.02	-1.				
AMRATE	.01	.4				

*The sensitivity of ELIMIT is not computed on the basis of percentage change.

Symbol: ALUMCS
Description: Alum Cost
Base Case: 5
Scheme #: 9

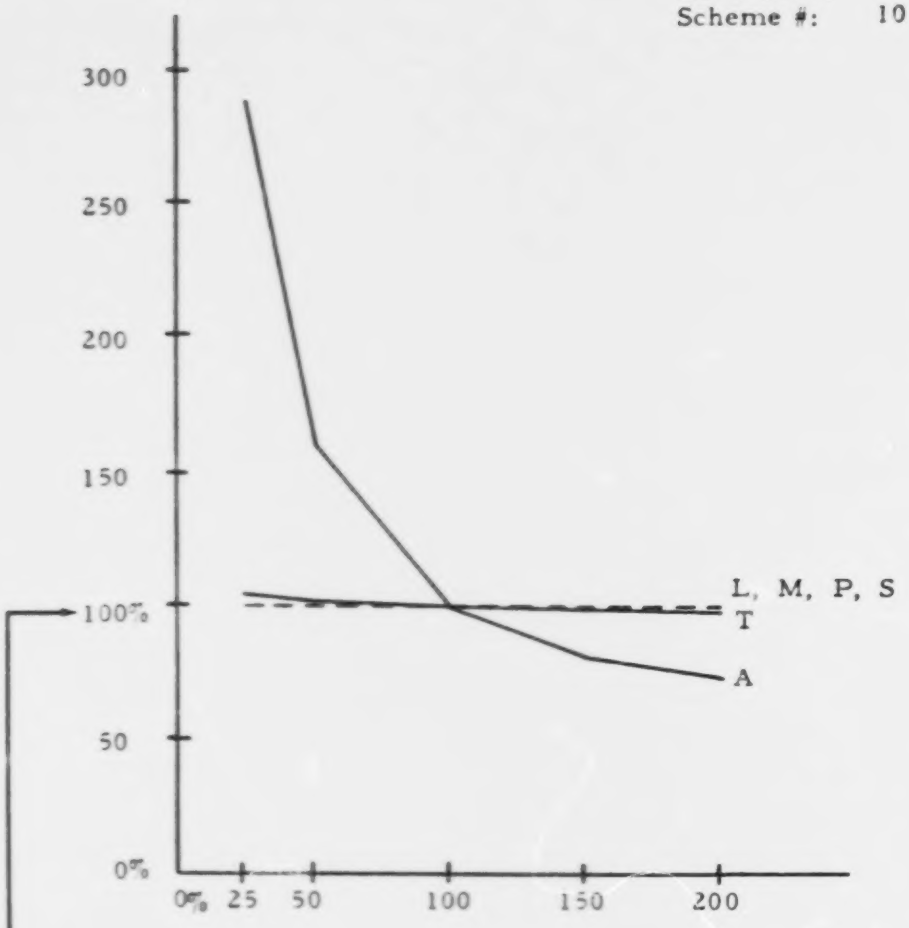


ALUMCS - .03 $/LB = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 5.4 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 7.2 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.9	0	0	.7
Slope over the range	0	0	.9	0	0	.7

Symbol: AMLIFE
Description: Amortization Life
Base Case: 5
Scheme #: 10

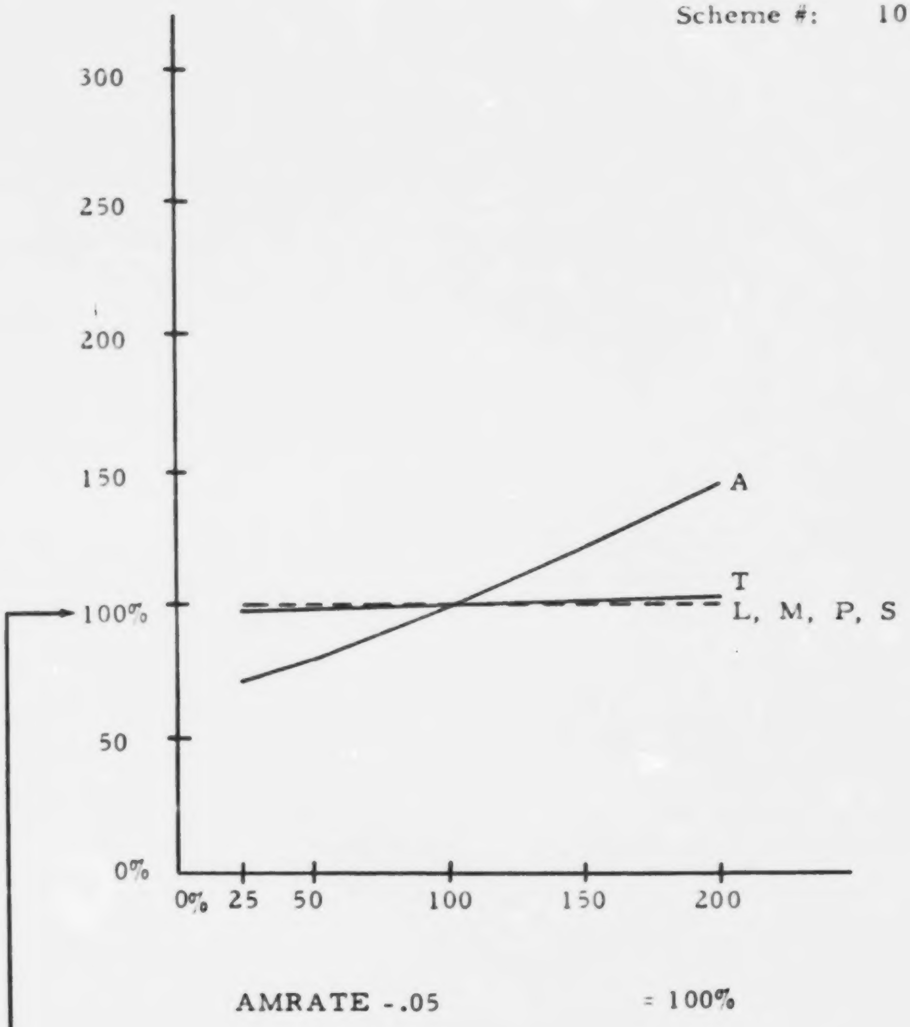


AMLIFE - 20 YEARS = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-0.8	0	0	0	0	-.03
Slope over the range	-1.2	0	0	0	0	-.03

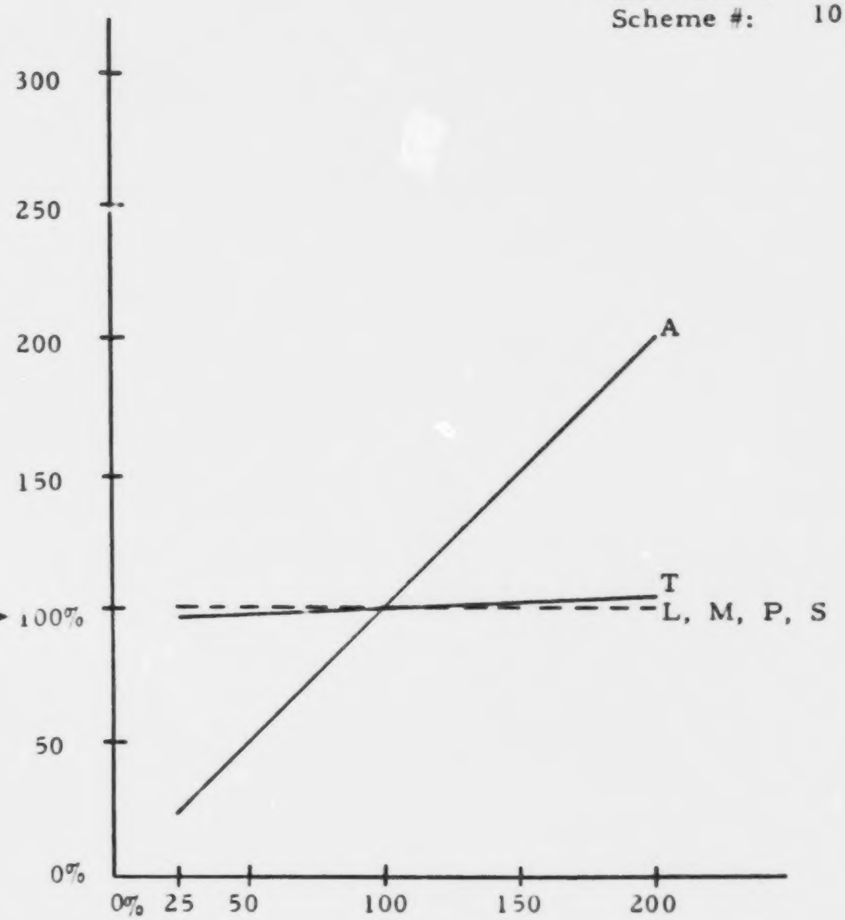
Symbol: AMRATE
Description: Amortization Rate
Base Case: 5
Scheme #: 10



A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.4	0	0	0	0	.01
Slope over the range	.4	0	0	0	0	.01

Symbol: CNSTRC
Description: WQO-STP Index
Base Case: 5
Scheme #: 10

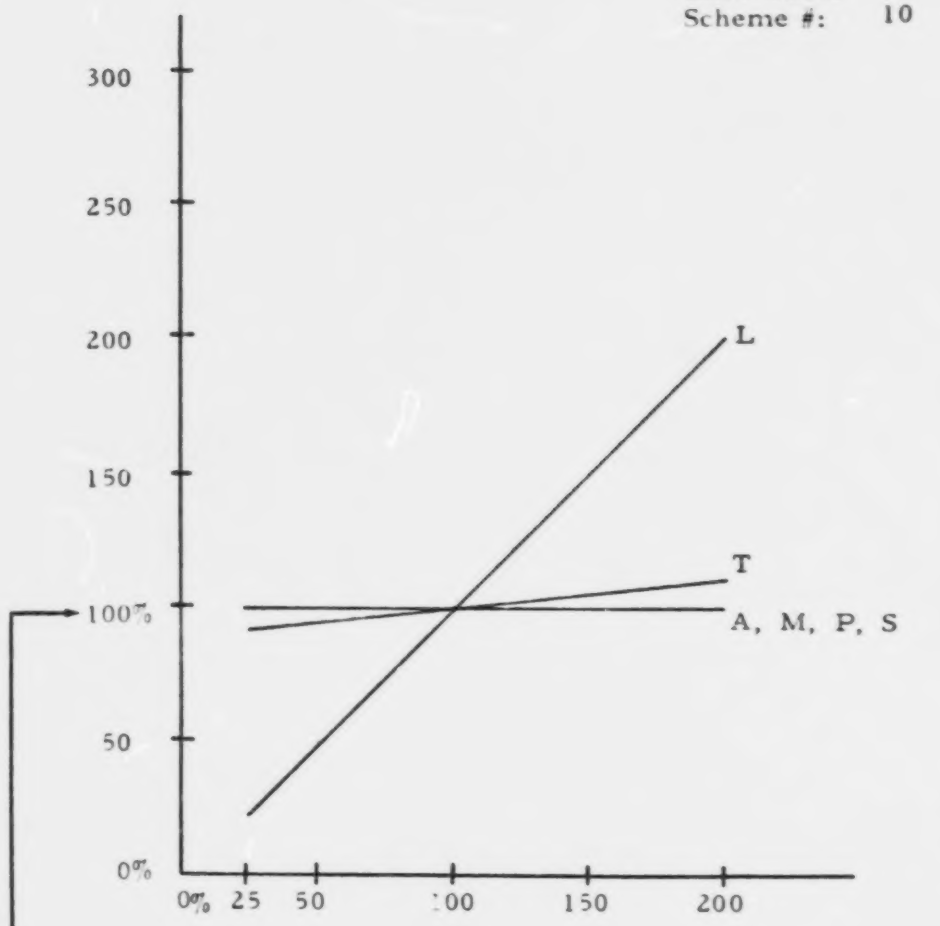


CNSTRC - 1.71 = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	1.	0	0	0	0	.02
Slope over the range	1.	0	0	0	0	.02

Symbol: DHR
Description: Labor Rate
Base Case: 5
Scheme #: 10

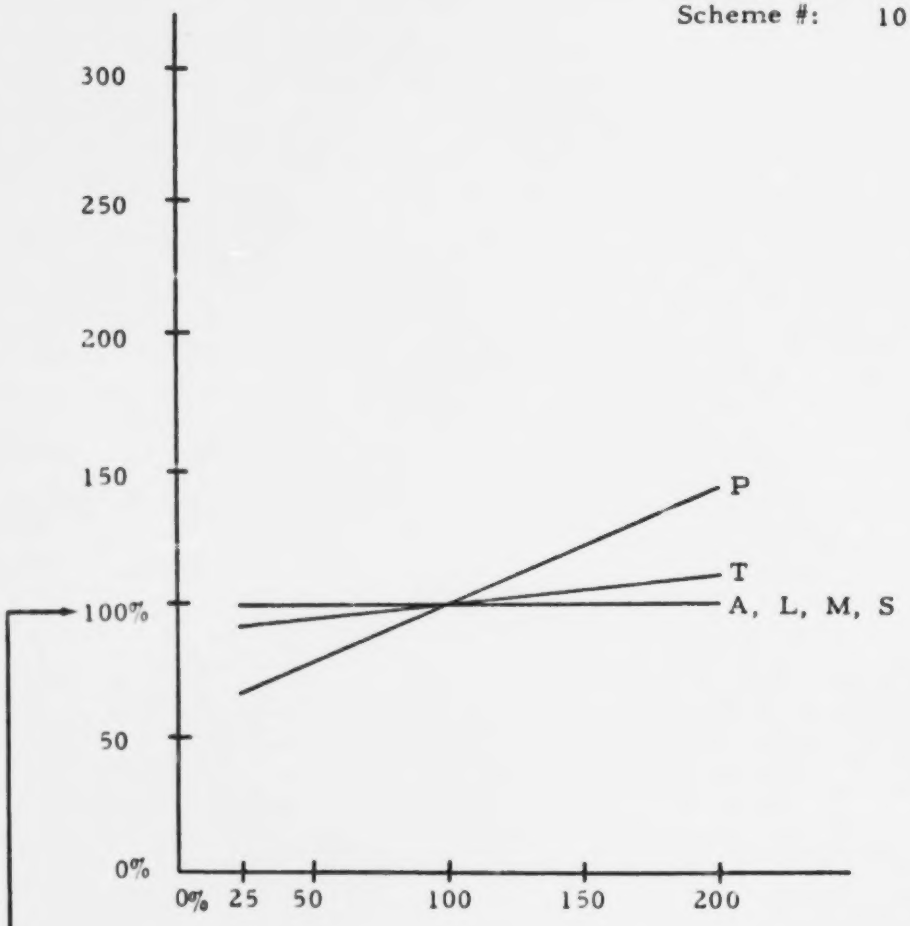


DHR - 3.10 $/HOUR = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	1.	0	0	0	.1
Slope over the range	0	1.	0	0	0	.1

Symbol:	DIFCOS
Description:	Detergent Cost
Base Case:	5
Scheme #:	10

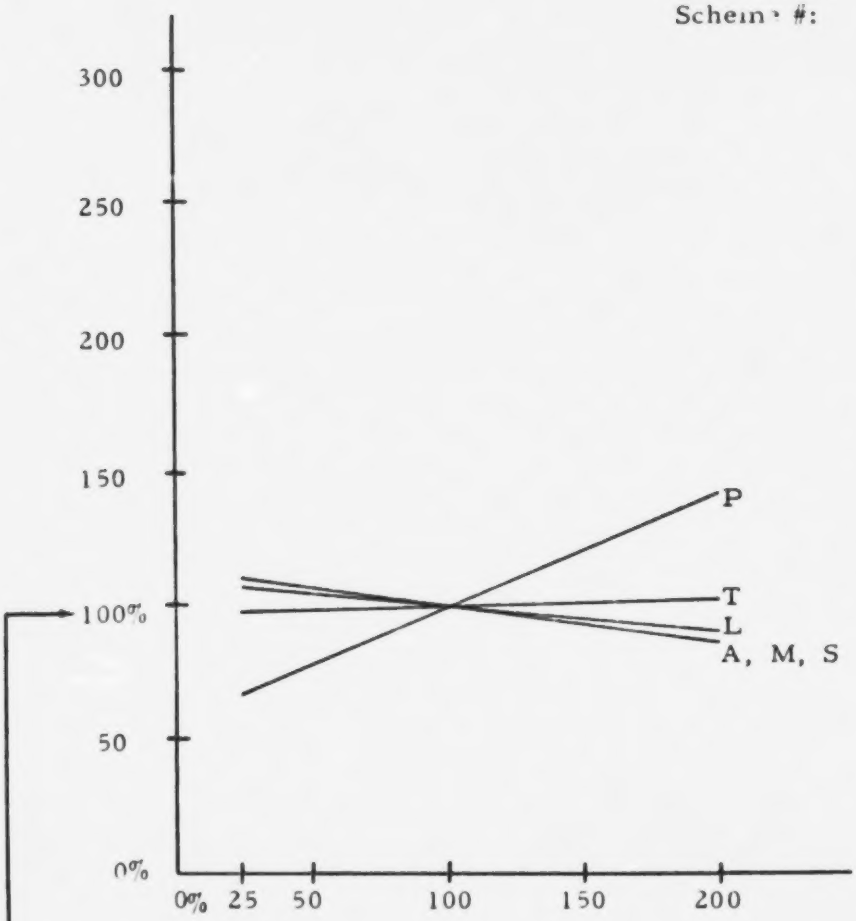


DIFCOS - .02 $/LB = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.4	0	.1
Slope over the range	0	0	0	.4	0	.1

Symbol: DTRGUS
Description: Detergent Use
Base Case: 5
Scheme #: 10

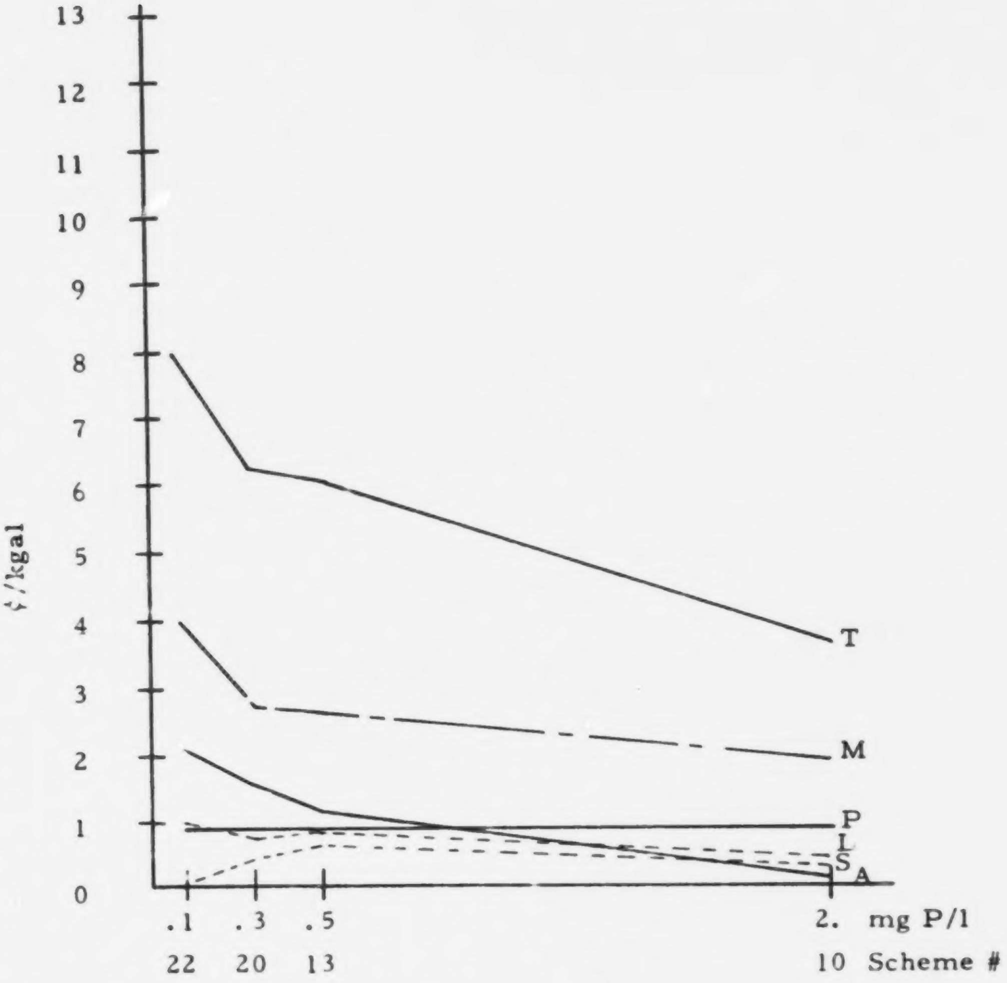


DTRGUS - 16 lb/capita/yr = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

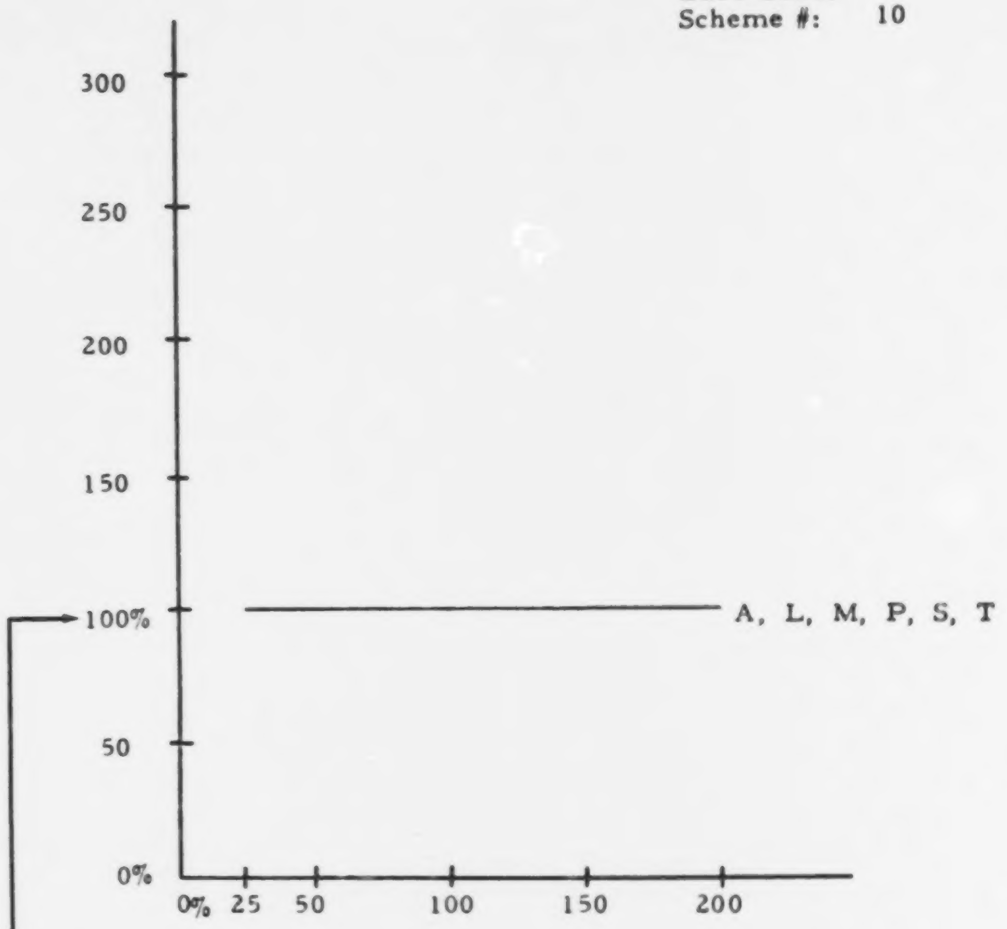
	A	L	M	P	S	T
Sensitivity at base point	-.14	-.09	-.14	.44	-.14	+.02
Slope over the range	-.14	-.09	-.14	.44	-.14	+.02

Symbol: ELIMIT
Description: Effluent Limit
Base Case: 5



A = Unit Amortization Cost
L = Unit Labor Cost
M = Unit Material & Supply Cost
P = Unit Detergent Limitation Cost
S = Unit Solid Sink Cost
T = Unit Total Cost

Symbol: ELECOS
Description: Electricity Cost
Base Case: 5
Scheme #: 10

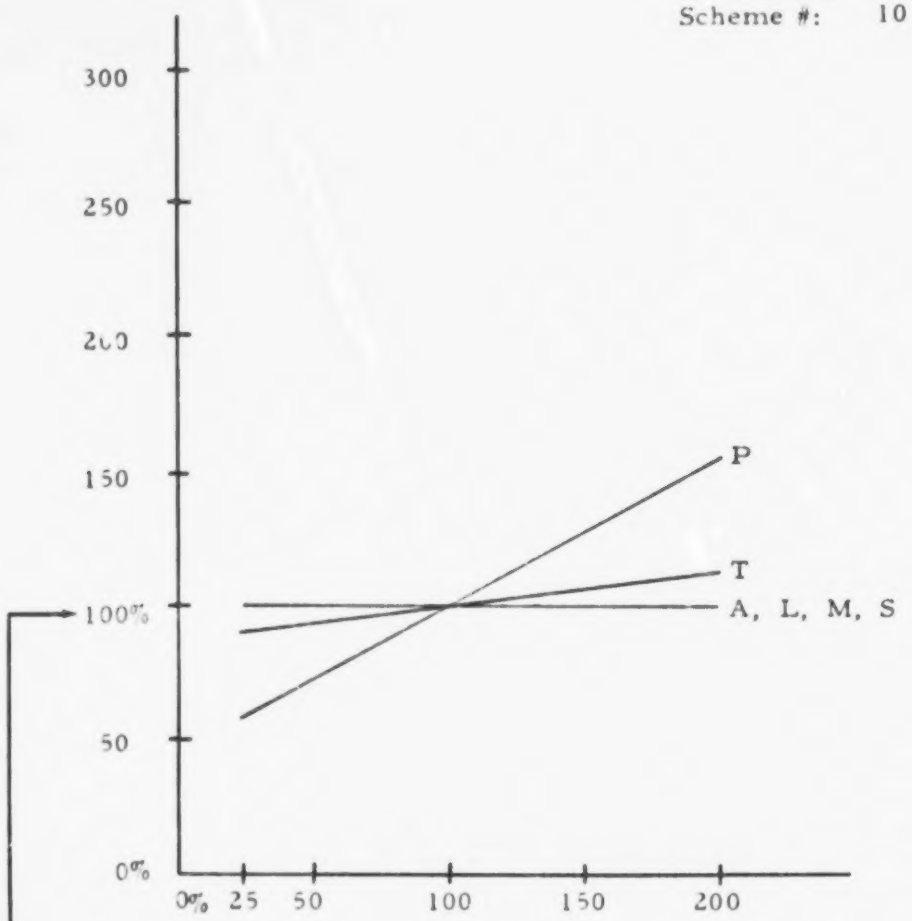


ELECOS - .0175 $/KWHR = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.3 ¢/kgal = 100%
S = Unit Solid Sink Cost - 3.6 ¢/kgal = 100%
T = Unit Total Cost - ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	0	0
Slope over the range	0	0	0	0	0	0

Symbol: ENFCST
Description: Enforcement Cost
Base Case: 5
Scheme #: 10

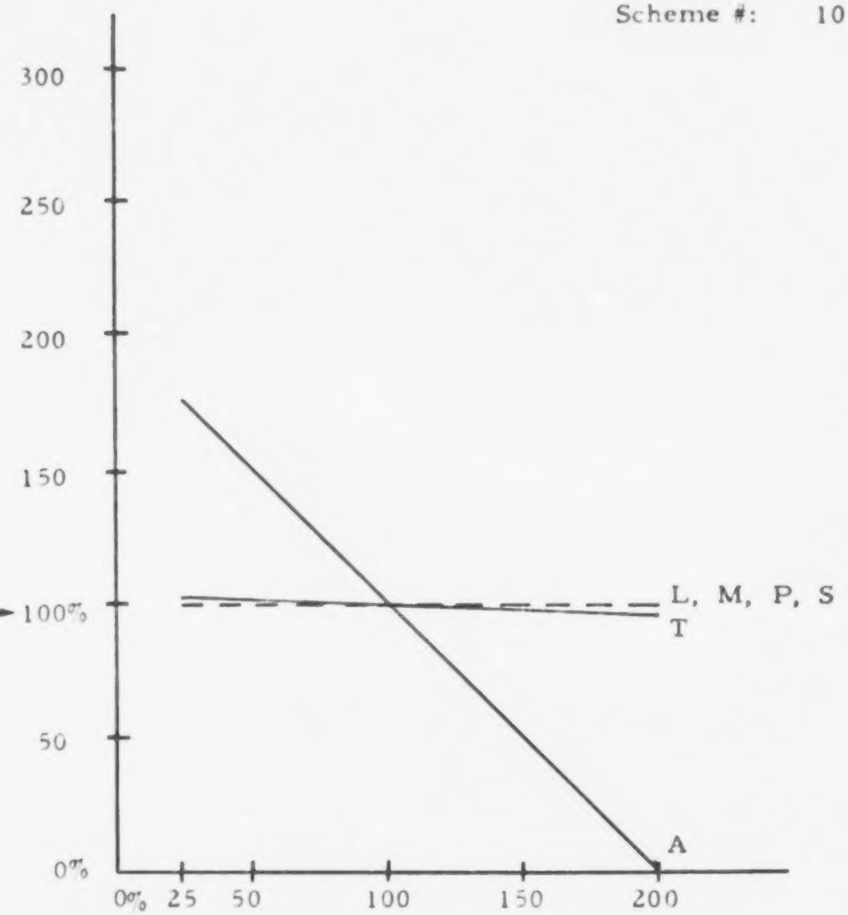


ENFCST - .4 \$/capita/yr = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	.6	0	.14
Slope over the range	0	0	0	.6	0	.14

Symbol: GOVFF
Description: Government
Base Case: 5 Financing
Scheme #: 10

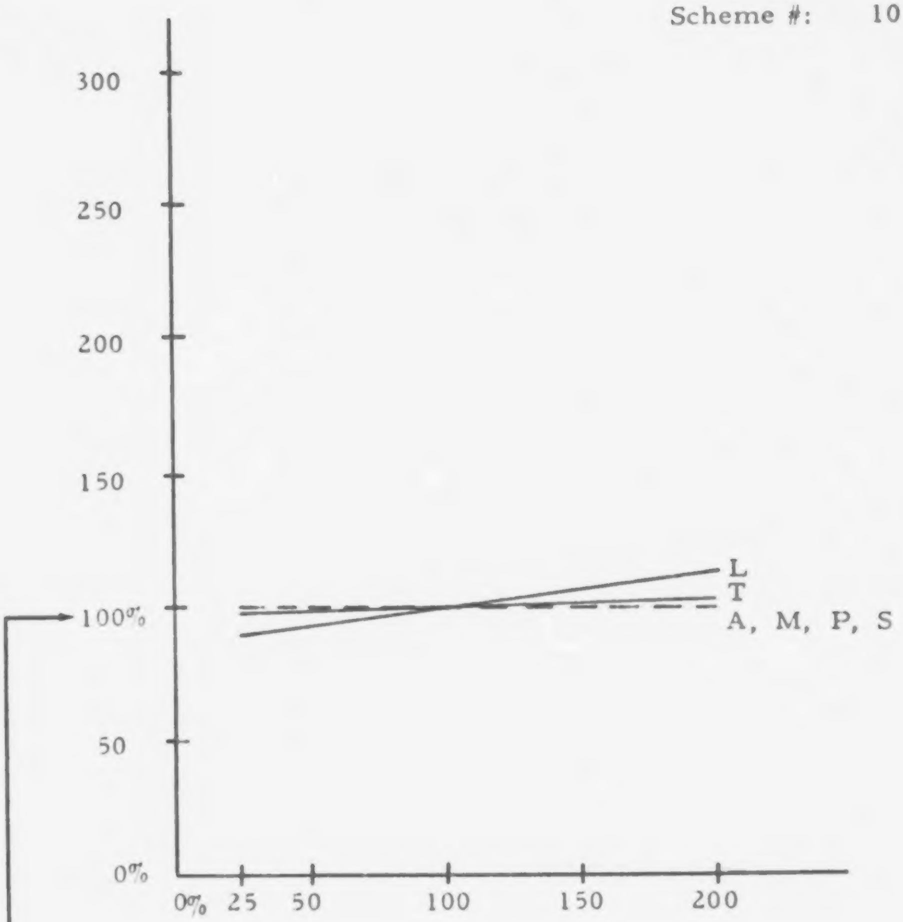


GOVFF - .5 = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	-1.	0	0	0	0	-.02
Slope over the range	-1.	0	0	0	0	-.02

Symbol: IDFRAC
Description: Indirect Labor
Base Case: 5
Scheme #: 10

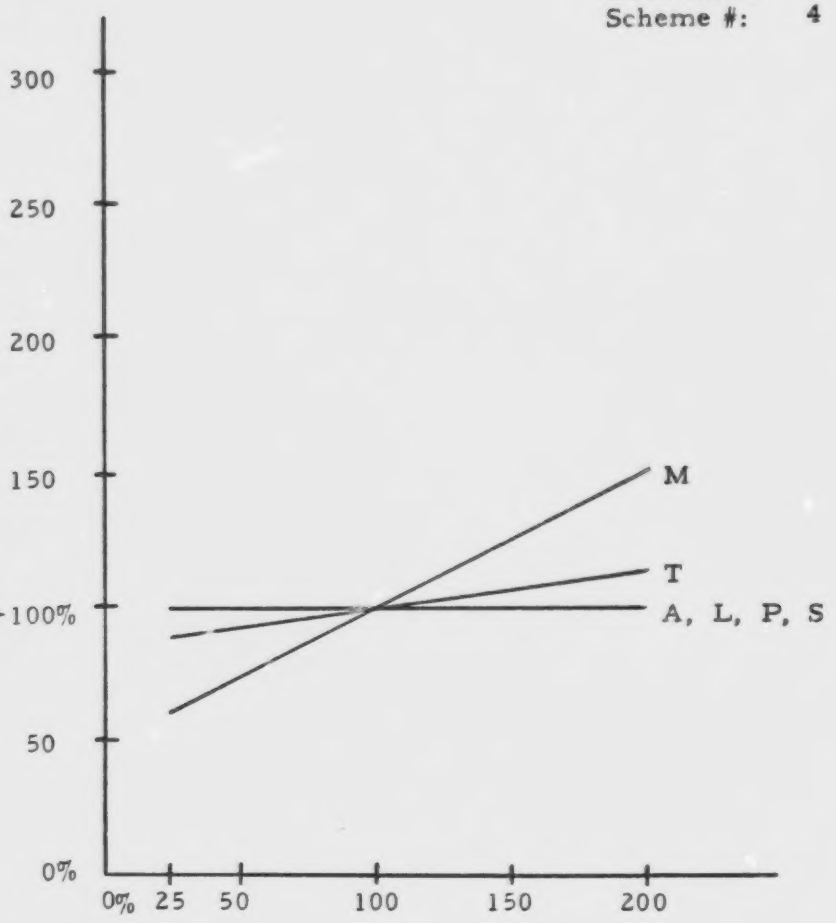


IDFRAC - .15 = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	.13	0	0	0	.01
Slope over the range	0	.13	0	0	0	.01

Symbol: LIMES
Description: Lime Cost
Base Case: 5
Scheme #: 4

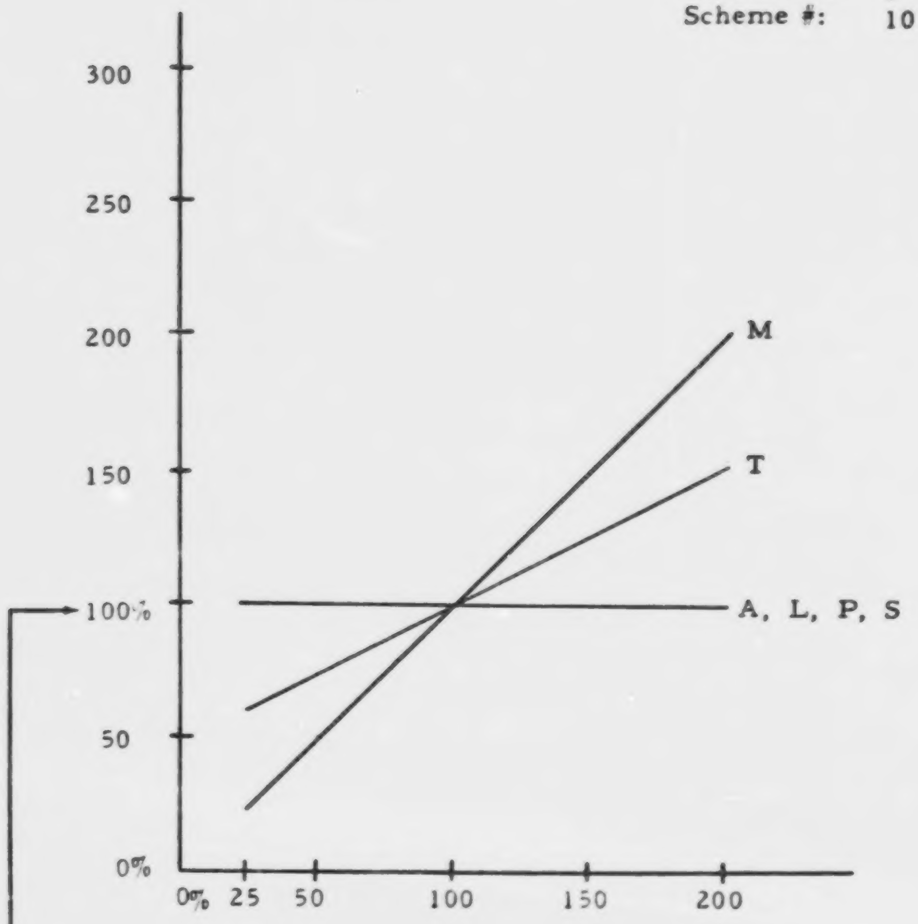


LIMECS - .01 $/LB = 100%

A = Unit Amortization Cost - 0.4 ¢/kgal = 100%
L = Unit Labor Cost - 1.7 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.8 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 2.0 ¢/kgal = 100%
T = Unit Total Cost - 6.7 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.5	0	0	.15
Slope over the range	0	0	.5	0	0	.15

Symbol: MATRLS
Description: Wholesale Price Index
Base Case: 5
Scheme #: 10

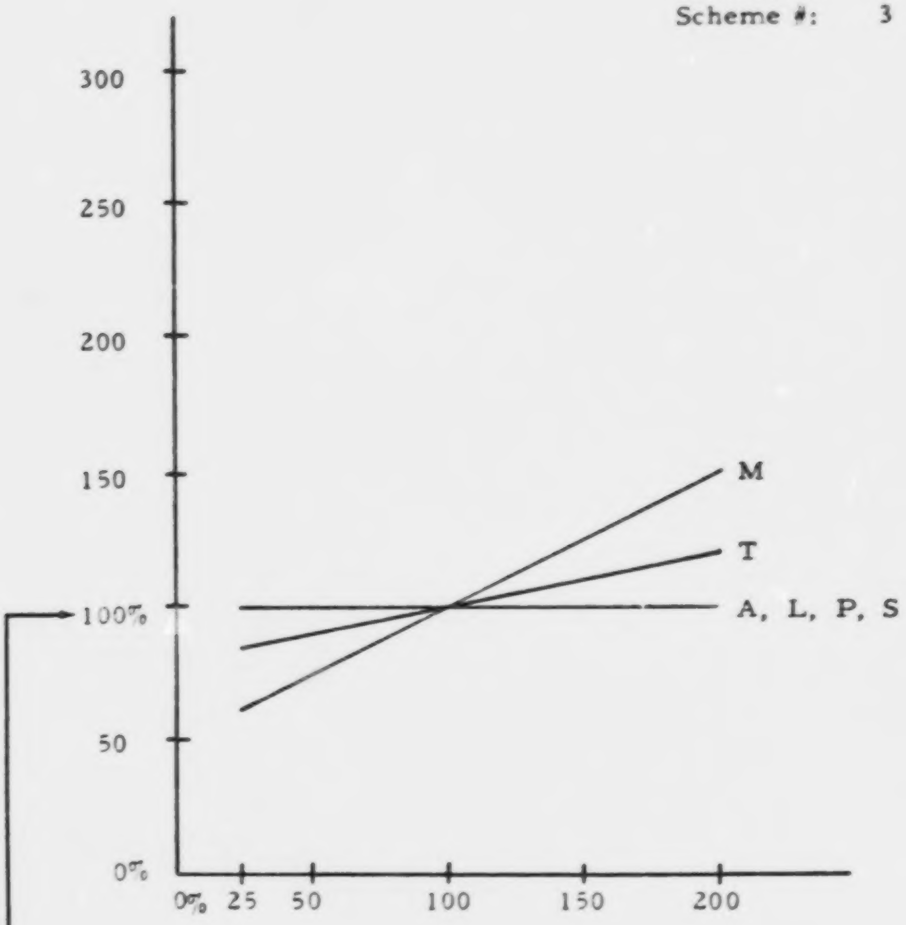


MATRLS - 1.18 = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	1.	0	0	.5
Slope over the range	0	0	1.	0	0	.5

Symbol: PCKLCS
Description: Pickle Liquor Cost
Base Case: 5
Scheme #: 3

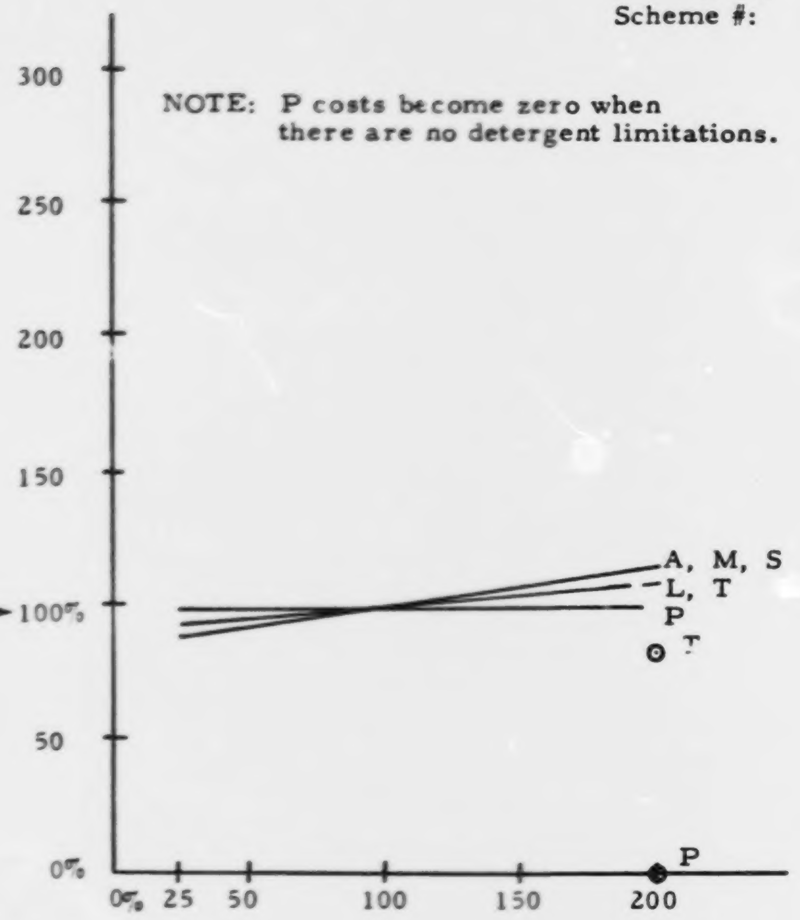


PCKLCS - .04 $/LB = 100%

A = Unit Amortization Cost - 0.7 ¢/kgal = 100%
L = Unit Labor Cost - 1.9 ¢/kgal = 100%
M = Unit Material & Supply Cost - 4.2 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 2.3 ¢/kgal = 100%
T = Unit Total Cost - 10.0 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	.5	0	0	.2
Slope over the range	0	0	.5	0	0	.2

Symbol: PCNTNT
Description: Detergent Phosphorus
Base Case: 5
Scheme #: 10

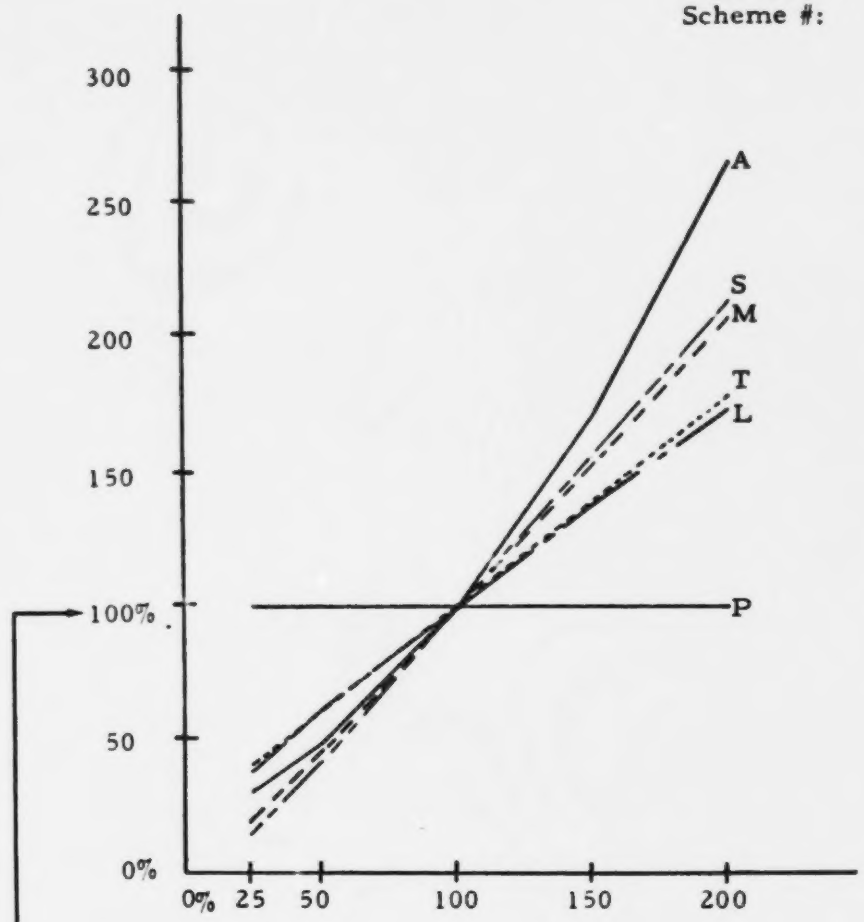

NOTE: P costs become zero when there are no detergent limitations.

PCNTNT - .05 = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	.14	.1	.14	0	.14	.1
Slope over the range	.14	.1	.14	0	.14	.1

Symbol: PINPS
Description: Influent Phosphorus
Base Case: 5
Scheme #: 10

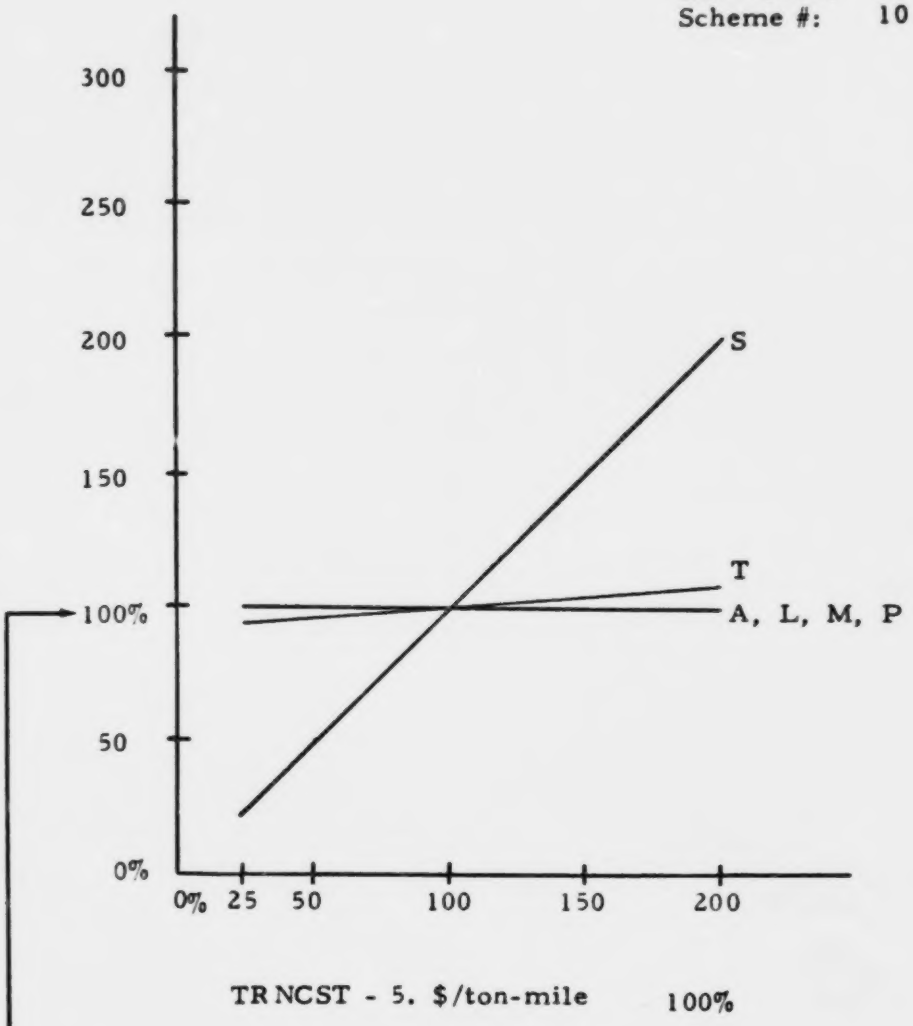


PINPS - 10 mg P/1 = 100%

A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	1.3	.8	1.	0	1.1	.8
Slope over the range	1.3	.8	1.	0	1.1	.8

Symbol: TRNCST
Description: Transportation Cost
Base Case: 5
Scheme #: 10



A = Unit Amortization Cost - 0.1 ¢/kgal = 100%
L = Unit Labor Cost - 0.4 ¢/kgal = 100%
M = Unit Material & Supply Cost - 1.9 ¢/kgal = 100%
P = Unit Detergent Limitation Cost - 0.9 ¢/kgal = 100%
S = Unit Solid Sink Cost - 0.3 ¢/kgal = 100%
T = Unit Total Cost - 3.6 ¢/kgal = 100%

	A	L	M	P	S	T
Sensitivity at base point	0	0	0	0	1.	.09
Slope over the range	0	0	0	0	1.	.09

SECTION V

SENSITIVITY ANALYSIS PROGRAM DESCRIPTION

The main sensitivity analysis program SARMVE is very similar to REMOVE which was written as part of EPA Contract No. 68-01-0758. The following subroutines of REMOVE were modified to permit easy (and less expensive) sensitivity analysis:

1. DTGLIM, the subroutine which reads in the restrictions on phosphorus in detergents and computes the new influent phosphorus levels, has been replaced by SADGLM. SADGLM reads in the restrictions but the computations have been moved to SARMVE because the computations must be done after the parameter values have been changed for the sensitivity analysis.

2. LCHOSE, the subroutine that determined which treatment schemes were eligible for consideration and also picked the alternative equivalent treatment process to correspond closely to the original plant configuration, has been replaced by SALCHS. SALCHS no longer determines the eligible treatment schemes because this is done by the user with previous runs of REMOVE for a particular case study and the treatment scheme for each parameter is placed in the array IPSCM.

3. REPORT, the subroutine which computes the unit treatment costs and prints out the costs and others, has been replaced by SARPRT. SARPRT computes the unit costs and places them in the array COSTS which is returned to SARMVE.

4. STRTGY, the subroutine which calls the various strategy determination subroutines, has been replaced by SASTGY. SASTGY is different from STRTGY only because it calls SADGLM instead of DTGLIM.

The input to SARMVE is identical to that of REMOVE with the following exception:

1. SARMVE reads in case number as the very first line of input. Because SARMVE has been designed to run in the batch mode there is no question asked for the case number.

2. SADGLM reads in only one (1) PCNTNT and PYEAR and there is no '99.' used to indicate end of detergent restriction data. This restriction is necessary in order to be able to perform sensitivity analysis of the variable PCNTNT.

SARMVE operates in the following manner:

1. Read in case number from Tape 5.

2. Write title and case number onto Tape 8.

3. Read in community and treatment plant description and the control strategy from Tape 5 the same as REMOVE does (with the noted exceptions above).

4. For MAXPRM parameters (PRMTR(IRPM)) and for MAXVAL values (VALUE(IVAL)) of the parameters compute the cost for the designated treatment scheme IPSCM (IPRM, ICASE) for each parameter and case.

5. Convert the costs to percentages of the base cost, i.e., the cost when the parameter assumes its initial value. Write these percentages onto Tape 8.

6. End.

The particular method of modification to REMOVE was chosen so that both REMOVE and SARMVE could reside in memory at the same time. This enables the user using a time sharing system to have both REMOVE and SARMVE on his/her disk without using large amounts of extra storage space. A copy of the modified subroutines and an example of the output of SARMVE follow.

```
FILE: SACOM    FORTRAN  P1                         INTERACTIVE DATA CORPORATION

C         COMMON BLOCK:
C            SACOM
C
C         PURPOSE:
C            CONTAINS  VARIABLES NECESSARY FOR SENSITIVITY ANALYSIS
C
C         VARIABLES:
C            COSTS(MESURE,IVAL) - THE UNIT COSTS (CENTS/KGAL)
C            IVAL   - INDEX OF PARAMETER VALUE
C            MESURE - INDEX OF COST MEASUREMENT
C            PYEAR  - YEAR CORRESPONDING TO PCNINT IN /DTHGNT/
C
C         AUTHOR:
C            DAVID A BARNES      14 MAR 73
C
C         ------------------------------------------------------------

      COMMON /SACOM/ COSTS(6,5), IVAL, PYEAR
      SUBROUTINE SADGLM
C
C        PURPOSE:
C           SADGLM READS IN THE PROPOSED LEGISLATIVE LIMIT ON THE
C           PHOSPHORUS CONTENT OF DETERGENTS AND THE IMPLEMENTATION
C           TIMES.
C
C        COMMON BLOCKS:
C           DTRGNT -  CHARACTERISTICS OF DETERGENTS AND USAGE
C           IELIMT -  INFLUENT AND EFFLUENT LIMITS
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           LIQUID -  LIQUID INFLUENT INFORMATION
C           SACOM  - VARIABLES USED IN SENSITIVITY ANALYSIS
C           SEWPOP -  THE SEWERED POPULATION
C           TIME   - PARAMETERS OF THE TIME HORIZON
C
C        CALLED BY:
C           SASTGY -  CONTROL STRATEGY CALLING ROUTINE
C
C        AUTHOR:
C           DAVID A BARNES   26 MAR 73
C
C        ---------------------------------------------------------------
      COMMON /DTRGNT/ DTRGUS, PCRATO, PPRATO, DIFCOS, PHESPC
     1               , PCTRG , ENFCST,  PSUBCS(20), PCNTNT

      REAL LEGPC

      COMMON /IELIMT/ IELIMT(2,20)
     1 , INF, EFF

      REAL IELIMT
      INTEGER EFF

      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1                , QPEAK, SSINPS, TBCDAR

      REAL MLSSAR, NH3IAR

      COMMON /SACOM/ COSTS(6,5), IVAL, PYEAR

      COMMON /SEWPOP/ FNCTYP, SPCPIN(2,5), SEWPOP(20)
     1 , YEAR, SPCP, MAXPV

      INTEGER YEAR, SPCP, FNCTYP

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF
```

```
FILE: SACGLM   FORTRAN  P1                          INTERACTIVE DATA CORPORATION

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

C         ---------- END OF COMMON BLOCKS

1010  FORMAT(1H ,'DETERGENT RETRICTIONS')
1951  FORMAT(1H ,'RESTRICT?')
1954  FORMAT(1H ,'DO YOU WANT TO IMPLEMENT PHOSPHATE DETERGENT RESTRICTI
     1ONS? (YES OR NO)')
2051  FORMAT(1H ,'DIFCOS=')
2054  FORMAT (1H 'DIFFERENTIAL COST BETWEEN OLD & NEW DETERGENT ($/LB DT
     1RGNT)')
2151  FORMAT(1H ,'DTRGUS=')
2154  FORMAT(1H ,'ANNUAL PER CAPITA DETERGENT USE (LBS/CAP/YR)')
2251  FORMAT(1H ,'ENFCST=')
2254  FORMAT(1H ,'ANNUAL PER CAPITA ENFORCEMENT COST OF P BAN ($/CAP)')
2651  FORMAT(1H ,'PRESPC=')
2654  FORMAT(1H ,'PRESENT P CONCENTRATION IN DETERGENTS (RATIO)')
3051  FORMAT (1H ,'PCNTNT=')
3054  FORMAT (1H ,'PROPOSED LEGISLATED PHOSPHORUS CONTENT IN DETERGENTS
     1(FLOAT,FRAC)')
4051  FORMAT (1H ,'PYEAR=')
4054  FORMAT (1H ,'YEAR OF IMPLEMENTATION (FLOAT)')
3510  FORMAT (1H ,'PCNTNT IS TOO LARGE, RESUBMIT PCNTNT + PYEAR')

C         **************************************************************
C         ****************                              ****************
C         ****************    START EXECUTION           ****************
C         ****************                              ****************
C         **************************************************************
C
1000  CONTINUE
      PRINT 1010
      DO 1500 TP = 1,MAXTP
      IELIMT(INF,TP) = PINPS
      PSUBCS(TP) = 0.
1500  CONTINUE
C
C         ASK USER IF HE/SHE DESIRES TO TRY DETERGENT CONTROL STRATEGY
1900  CONTINUE
1950  PRINT 1951
1952  CALL READIN(ALPHA)
      GO TO (1953,1900,1955,1950,1956),  IGOTO
1953  PRINT 1954
      GO TO 1952
1955  IANSWR = NO
      GO TO 1957
1956  CONTINUE
1957  CONTINUE
      IF (IANSWR .EQ. YES)  GO TO 2000
      IF (IANSWR .EQ. NO)  RETURN
      GO TO 1900
2000  CONTINUE
```

```
C          READ IN DETERGENT INFORMATION
2050  PRINT 2051
2052  CALL READIN(FLOTE)
      GO TO (2053,2000,2055,2050,2056),  IGOTO
2053  PRINT 2054
      GO TO 2052
C          .02 $/LB FROM REF. 1.,P. 15 AND REF 11.
C          ASSUMING THAT 1 LB OF DETERGENT CONTAINS 0.4 LB OF PHOSPHATE OR
C          ITS SUBSTITUTE
2055  DIFCOS = .02
      GO TO 2057
2056  DIFCOS = ANSWER
2057  CONTINUE
2150  PRINT 2151
2152  CALL READIN(FLOTE)
      GO TO (2153,2000,2155,2150,2156),  IGOTO
2153  PRINT 2154
      GO TO 2152
C          27 LBS/CAPITA/YEAR FROM REF. 2
2155  DTRGUS = 27.
      GO TO 2157
2156  DTRGUS = ANSWER
2157  CONTINUE
2250  PRINT 2251
2252  CALL READIN(FLOTE)
      GO TO (2253,2000,2255,2250,2256),  IGOTO
2253  PRINT 2254
      GO TO 2252
C          $.40/CAPITA/YEAR FROM REF. 3
2255  ENFCST = .40
      GO TO 2257
2256  ENFCST = ANSWER
2257  CONTINUE
C          PDRATO = WEIGHT RATIO OF PHOSPHATE TO DETERGENT
C          .4 FROM REF. 4
      PDRATO = .4
C          PPRATO = WEIGHT RATIO OF PHOSPHORUS TO PHOSPHATE
C          .25 FROM REF. 5
      PPRATO = .25
2650  PRINT 2651
2652  CALL READIN(FLOTE)
      GO TO (2653,2000,2655,2650,2656),  IGOTO
2653  PRINT 2654
      GO TO 2652
C          NEGATIVE NUMBER WILL CAUSE PRESPC=PDRATO*PPRATO IN 'SADGLM'
2655  PRESPC = -1.
      GO TO 2657
2656  PRESPC = ANSWER
2657  CONTINUE
C
C          READ IN LEGISLATED PHOSPHORUS CONTENT
3050  PRINT 3051
3052  CALL READIN(FLOTE)
      GO TO (3053,1000,3055,3050,3056),  IGOTO
3053  PRINT 3054
```

```
      GO TO 3052
3055  PCNTNT = 99.
      GO TO 3057
3056  PCNTNT = ANSWER
3057  CONTINUE
C
C        READ IN IMPLEMENTATION YEAR ASSOCIATED WITH PCNTNT
4050  PRINT 4051
4052  CALL READIN(FLOTE)
      GO TO (4053,1000,4055,4050,4056),  IGOTO
4053  PRINT 4054
      GO TO 4052
4055  PYEAR = 0.
      GO TO 4057
4056  PYEAR = ANSWER
4057  CONTINUE
      RETURN
C
C        END OF SUBROUTINE SADGLM
      END
      SUBROUTINE SALCHS
C
C        PURPOSE:
C           SALCHS SELECTS EQUIVALENT TREATMENT PROCESS TO CONFORM
C           AS CLOSELY AS POSSIBLE TO THE PRESENT PLANT CONFIGURATION.
C
C        COMMON BLOCKS:
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
C           TPLANT - INFO ABOUT TREATMENT PLANT PROCESSES
C
C        CALLED BY:
C           SAMMVE - THE MAIN SENSITIVITY ANALYSIS PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES   13 MAR 73
C
C        ---------------------------------------------------------------
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP


      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGDCN, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLCTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGDCN, RECFB1, RECFB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PAPMX

C        ****************************************************************
C        ****************                                ****************
C        ****************    START EXECUTION             ****************
C        ****************                                ****************
C        ****************************************************************
C
1000  CONTINUE
      ISCH = ISCHM
C
C        IF SCHEME(J) CAN HAVE ALTERNATIVE EQUIVALENT PROCESSES, THEN
C        MAKE IT MATCH PRESENT PLANT CONFIGURATION AS CLOSE AS POSSIBLE.
      IF ((ISCH .LE. 8) .OR. ((ISCH .GE. 19) .AND. (ISCH .LE. 22)))
     1  GO TO 3300
      IF (ISCH .LE. 14)  GO TO 3500
      GO TO 6000
3300  CONTINUE
C
C        GO TO END OF PROCESS DATA IN SCHEME J
      DO 3350 ILIQ = 1,25
      IF (SCHEME(ILIQ,ISCH) .LE. 0 )  GO TO 3400
3350  CONTINUE
C
C        ADD ALTERNATIVE PROCESSES TO LIST OF REQUIRED EQUIPMENT
C
C        DETERMINE BIOLOGICAL TREATMENT METHOD, DEFAULT IS
C        ACTIVATED SLUDGE
3400  CONTINUE
      SCHEME(ILIQ,ISCH) = AERBSN
      IF (TPLANT(PPARM,TRKFTR) .EQ. 0.)  GO TO 3430
      SCHEME(ILIQ,ISCH) = TRKFTR
      GO TO 6000
C
C        DETERMINE METHOD OF AERATION, DEFAULT IS MECHANICAL AERATION
3430  ILIQ = ILIQ + 1
3450  CONTINUE
      SCHEME(ILIQ,ISCH) = MCHAER
      IF (TPLANT(PPARM,DIFAIR) .NE. 0.)  SCHEME(ILIQ,ISCH) = DIFAIR
      GO TO 6000
3500  CONTINUE
C
C        GO TO END OF PROCESS DATA IN SCHEME J
      DO 3550 ILIQ = 1,25
      IF (SCHEME(ILIQ,ISCH) .LE. 0)  GO TO 3450
3550  CONTINUE
6000  CONTINUE
C
C        END OF SUBROUTINE SALCHS
      RETURN
      END
```

```
FILE: SARMVE   FORTRAN  P1                        INTERACTIVE DATA CORPORATION

C         PROGRAM NAME:
C            SARMVE
C
C         PURPOSE:
C            THIS IS THE MAIN SENSITIVITY ANALYSIS PROGRAM. IT IS
C            VERY SIMILAR TO 'REMOVE', WHICH WAS WRITTEN AS PART OF
C            EPA CONTRACT NO. 68-01-0758.  THE FOLLOWING SUBROUTINES
C            OF 'REMOVE' HAVE BEEN MODIFIED:
C            1. DTGLIM IS REPLACED BY SADGLM
C            2. LCHOSE IS REPLACED BY SALCHS
C            3. REPORT IS REPLACED BY SARPRT
C            4. STRTGY IS REPLACED BY SASTGY
C            THE INPUT TO 'SARMVE' IS IDENTICAL TO THAT OF 'REMOVE'
C            WITH THE FOLLOWING EXCEPTIONS:
C            1. SARMVE READS IN A CASE NUMBER AS THE VERY FIRST LINE
C               OF INPUT.
C            2. SADGLM READS IN ONLY ONE (1) 'PCNTNT' & 'PYEAR' AND
C               THERE IS NO '99.' USED TO INDICATE END OF DATA.
C            'SARMVE' OPERATES IN THE FOLLOWING MANNER:
C            1. READ IN A CASE NUMBER FROM TAPE 5.
C            2. WRITE TITLE & CASE NO. ONTO TAPE 8.
C            3. READ IN COMMUNITY & PLANT DESCRIPTION AND STRATGY FROM
C               TAPE 5 THE SAME AS 'REMOVE' DOES (WITH NOTED EXCEPTIONS).
C            4. FOR 'MAXPRM' PARAMETERS ('PRMTR(IPRM)') AND FOR 'MAXVAL'
C               VALUES ('VALUE(IVAL)') OF THOSE PARAMETERS COMPUTE THE
C               COST FOR THE LOWEST COST APPRPRIATE TREATMENT SCHEME.
C               (THE SCHEME FOR EACH PARAMETER AND CASE IS CONTAINED IN
C               'IPSCM(IPRM,ICASE)').
C            5. CONVERT THE COSTS TO PERCENTAGES OF THE COSTS WHEN HE
C               PARAMETER IS UNCHANGED (ITS BASE VALUE).  WRITE THESE
C               PERCENTAGES ONTO TAPE 8.
C            6. END
C            NOTE 1: THIS PROGRAM WAS DESIGNED TO RUN ON AN IBM 360/67
C            TIME SHARING SYSTEM.  SPECIFICALLY, THAT OF, INTERACTIVE
C            DATA CORP., WALTHAM, MASS. (617-890-1234).
C            A CORE SIZE OF 304K BYTES WAS REQUIRED FOR EXECUTION.
C            NOTE 2: THE BASIC STUCTURE OF THE COST EQUATIONS WAS TAKEN
C            FROM REF. 10 AND FOR THIS WE ARE EXTREMELY GRATEFUL TO
C            RICHARD EILERS AND ROBERT SMITH OF EPA-CINCINNATI FOR THEIR
C            FINE WORK WHICH WE BUILT UPON.
C            NOTE 3: THE PROGRAM CORE AREA MUST BE SET TO ZERO BEFORE
C            LOADING THE OBJECT MODULE.  THIS IS NECESSARY BECAUSE
C            CERTAIN SUBROUTINES ASSUME THAT ZERO MARKS THE END OF DATA
C            INTO CERTAIN ARRAYS.
C
C         COMMON BLOCKS:
C            CHMCST - COST OF CHEMICALS
C            DTRGNT - DETERGENT RESTRICTION INFORMATION
C            ENGCST - COST OF ENERGY
C            IELIMT - INFLUENT/EFFLUENT LIMITS
C            LBRCST - COST OF LABOR
C            LIQUID - LIQUID INFLUENT INFORMATION
C            PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C            PRNTR  - CONTAINS PRINTOUT CONTROL VARIABLES
C            SACOM  - SENSITIVITY ANALYSIS VARIABLES
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C              SCHEME - CHARACTERISTICS OF LIQUID TREATMENT SCHEMES
C              SEWPOP - THE SEWERED POPULATION
C              SSINK  - SOLID SINK INFORMATION
C              TIME   - THE TIME HORIZON
C              TPLANT - TREATMENT PLANT CHARACTERISTICS
C              TSCST  - TIME & SPACE DIFFERENCE COSTS
C
C           SUBROUTINES CALLED:
C              SALCHS - SELECT EQUIVALENT ALTERNATIVE LIQUID PROCESSES
C              SARPRT  - COMPUTE SUMMARY OF COST INFO FOR SCHEME
C              SSKCST  - COMPUTE COSTS OF FEASIBLE SOLID SINKS
C              SASTGY  - INPUT CONTROL STRATEGY
C              SYSTEM  - INPUT DESCRIPTION OF COMMUNITY, SEWAGE, PLANT
C              TRTMNT  - COMPUTE COST OF LIQUID AND SLUDGE TREATMENT
C
C
C           NUMERIC CONSTANTS:
C                   .020825 = POUNDS/GAL FOR LIQUID POLYMER
C                   .029    = ASSUMED RATIO OF TRICKLING FILTER SLUDGE
C                             WASTING STREAM VOLUME TO INPUT VOLUME
C                   .075    = POUNDS OF AIR/CUBIC FOOT
C                   .123    = POUNDS OF CO2/ CUBIC FOOT
C                   .125    = ENDOGENOUS RESPIRATION CONSTANT AT 20C
C                   .232    = POUNDS OF O2/ POUND OF AIR
C                   .4902   = POUNDS/GAL FOR LIQUID ALUM
C                   .6      = ASSUMED FRACTION OF MLVSS WHICH ARE ACTIVE
C                   .7      = ASSUMED RATIO OF MIXED LIQUOR VOLATILE
C                             SUSPENDED SOLIDS TO MLSSAR
C                   .7457   = KILOWATTS/HORSEPOWER
C                  1.506    = WQO-STP INDEX FOR JAN 71 NATIONAL AVERAGE $
C                  2.27     = POUNDS OF FECL2/POUND OF FE
C                  2.6      = POUNDS/GAL FOR FECL2
C                  2.89     = POUND OF FECL3/ POUND OF FE
C                  3.95     = POUNDS/GAL FOR FECL3
C                  4.22     = POUNDS OF NAAL/POUND OF AL
C                  5.4      = POUNDS/GAL FOR ALUM
C                  3.4      = (ASSUMED) POUNDS/GAL FOR NAAL
C                  6.       = ASSUMED DEPTH OF TRICKLING FILTER MEDIA
C                  7.48     = GALLONS/CUBIC FOOT FOR WATER
C                  8.33     = POUNDS/GAL FOR WATER
C                 11.       = POUNDS OF ALUM/POUND OF AL
C                 24.       = HOURS/DAY
C                 30.       = DAYS/MONTH
C                 60.       = MINUTES/HOUR
C                180.       = ASSUMED CONCENTRATION OF SUSPENDED SOLIDS IN
C                             TRICKLING FILTER SLUDGE WASTING STREAM
C                365.       = DAYS/YEAR
C               1440.       = MINUTES/DAY
C               2000.       = POUNDS/TON
C              43560.       = SQUARE FEET/ACRE
C
C           AUTHOR:
C              DAVID A BARNES   29 MAR 73
C              JRB SCIENTIFIC CORP.
C              2 DAY AVENUE
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C             BURLINGTON, MA  01803
C             (617-273-0270)
C
C        ------------------------------------------------------------
      COMMON / CHMCST/ LIMECS, ALUMCS, POLYCS, FECLCS, NAALCS, PCKLCS
     1                 , NAOHCS, CO2CS
      REAL LIMECS, NAALCS, NAOHCS
      COMMON /DTRGNT/ DTFGUS, PDRATO, PPRATO, DIFCOS, PRESPC
     1                 , PDTRG , ENFCST,  PSUBCS(20), PCNTNT
      REAL LEGFC
      COMMON /ENGCST/ ELECOS, OILCOS, GASCOS
      COMMON /IELIMT/ IELIMT(2,20)
     1 , INF, EFF
      REAL IELIMT
      INTEGER EFF
      COMMON /LBRCST/ DHR, IDFRAC, GOVFF
      REAL IDFRAC
      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1                 , QPEAK, SSINPS, TBODAR
      REAL MLSSAR, NH3IAR
      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY
      EQUIVALENCE (IANSWR,ANSWER)
      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF
      COMMON /PRNTR/ ISHORT, ISUPER, ISKIP, IPASS, ISELCT(5)
      COMMON /SACCM/ COSTS(6,5), IVAL, PYEAR
      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, LIFBAS, L2FBAS, NONE
     4 , EQUIP(45)
      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFPAS
      REAL MINEFP

      COMMON /SEWPOP/ FNCTYP, SPCPIN(2,5), SEWPOP(20)
     1 , YEAR, SPCP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /SSINK/ TRNCST, SWASTE(20), SCLSNK(2,15), SSCOST(20)
     1              , BESTSS(20), CAP, DIST, MAXSS
      INTEGER BESTSS, CAP, DIST


      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGCON, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, POLYFS
     6 , CO2FS , NACLFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , PPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP

      INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
     1 , DIFAIR, FLOCCP, SECSET, RE1PMP, CLFEED, CLBASN, RE2PMP
     2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
     3 , CENFUG, FBINC , WSPOND, SLGCON, RECRB1, RECRB2, TERST1
     4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
     5 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX


      COMMON /TSCST/ CNSTRC, MATRLS

      REAL MATRLS

C         ----------END OF COMMON BLOCKS

      DIMENSION IPSCM(20,5), PRMTR(20), PERCNT(6,5),VALUE(5)
      DIMENSION PRINTM(6), PRINTN(20,2)


      DATA VALUE(1)/.25/, VALUE(2)/.5/, VALUE(3)/1./, VALUE(4)/1.5/
     1 , VALUE(5)/2./
      DATA MAXPRM/17/, MAXVAL/5/
      DATA MAXMES/6/, IHUN/3/
C         NAMES OF MEASURES FOR PRINTING
      DATA PRINTM(1)/1HA/, PRINTM(2)/1HL/, PRINTM(3)/1HM/
     1 , PRINTM(4)/1HP/,  PRINTM(5)/1HS/, PRINTM(6)/1HT/
C         NAMES OF PARAMETERS UNDERGOING SENSITIVITY ANALYSIS
```

```
      DATA PRINTN(1,1)/4HALUM/, PRINTN(1,2)/2HCS/
      DATA PRINTN(2,1)/4HAMLI/, PRINTN(2,2)/2HFE/
      DATA PRINTN(3,1)/4HAMPA/, PRINTN(3,2)/2HTE/
      DATA PRINTN(4,1)/4HCNST/, PRINTN(4,2)/2HRC/
      DATA PRINTN(5,1)/4HDHR /, PRINTN(5,2)/2H  /
      DATA PRINTN(6,1)/4HDIFC/, PRINTN(6,2)/2HDS/
      DATA PRINTN(7,1)/4HDTRG/, PRINTN(7,2)/2HUS/
      DATA PRINTN(8,1)/4HELEC/, PRINTN(8,2)/2HDS/
      DATA PRINTN(9,1)/4HENFC/, PRINTN(9,2)/2HST/
      DATA PRINTN(10,1)/4HIDEP/, PRINTN(10,2)/2HAC/
      DATA PRINTN(11,1)/4HLIME/, PRINTN(11,2)/2HCS/
      DATA PRINTN(12,1)/4HMSTE/, PRINTN(12,2)/2HLS/
      DATA PRINTN(13,1)/4HPCKL/, PRINTN(13,2)/2HCS/
      DATA PRINTN(14,1)/4HPCNT/, PRINTN(14,2)/2HNT/
      DATA PRINTN(15,1)/4HPINP/, PRINTN(15,2)/2HS /
      DATA PRINTN(16,1)/4HTRNF/, PRINTN(16,2)/2HST/
      DATA PRINTN(17,1)/4HGOVF/, PRINTN(17,2)/2HF /
C        INITIALIZE IPSCM(IPAM,ICASE) WITH CORRECT SCHEME NUMBERS
C        FOR EACH PARAMETER AND CASE
C        CASE 1  THE MARLBORO PLANT
      DATA IPSCM( 1,1)/ 9/, IPSCM( 2,1)/10/, IPSCM( 3,1)/10/
     1   , IPSCM( 4,1)/10/, IPSCM( 5,1)/10/, IPSCM( 6,1)/10/
     2   , IPSCM( 7,1)/10/, IPSCM( 8,1)/10/, IPSCM( 9,1)/10/
     3   , IPSCM(10,1)/10/, IPSCM(11,1)/ 4/, IPSCM(12,1)/10/
     4   , IPSCM(13,1)/ 3/, IPSCM(14,1)/10/, IPSCM(15,1)/10/
     5   , IPSCM(16,1)/10/, IPSCM(17,1)/10/
C        CASE 2  THE MDC CLINTON PLANT
      DATA IPSCM( 1,2)/15/, IPSCM( 2,2)/15/, IPSCM( 3,2)/15/
     1   , IPSCM( 4,2)/15/, IPSCM( 5,2)/15/, IPSCM( 6,2)/15/
     2   , IPSCM( 7,2)/15/, IPSCM( 8,2)/15/, IPSCM( 9,2)/15/
     3   , IPSCM(10,2)/15/, IPSCM(11,2)/ 3/, IPSCM(12,2)/15/
     4   , IPSCM(13,2)/ 3/, IPSCM(14,2)/15/, IPSCM(15,2)/15/
     5   , IPSCM(16,2)/15/, IPSCM(17,2)/15/
C        CASE 3  THE HYPOTHETICAL TRICKLING FILTER PLANT
      DATA IPSCM( 1,3)/15/, IPSCM( 2,3)/15/, IPSCM( 3,3)/15/
     1   , IPSCM( 4,3)/15/, IPSCM( 5,3)/15/, IPSCM( 6,3)/15/
     2   , IPSCM( 7,3)/15/, IPSCM( 8,3)/15/, IPSCM( 9,3)/15/
     3   , IPSCM(10,3)/15/, IPSCM(11,3)/ 3/, IPSCM(12,3)/15/
     4   , IPSCM(13,3)/ 3/, IPSCM(14,3)/15/, IPSCM(15,3)/15/
     5   , IPSCM(16,3)/15/, IPSCM(17,3)/15/
C        CASE 4  THE BROCKTON PLANT
      DATA IPSCM( 1,4)/ 1/, IPSCM( 2,4)/ 2/, IPSCM( 3,4)/ 2/
     1   , IPSCM( 4,4)/ 2/, IPSCM( 5,4)/ 2/, IPSCM( 6,4)/ 2/
     2   , IPSCM( 7,4)/ 2/, IPSCM( 8,4)/11/, IPSCM( 9,4)/ 2/
     3   , IPSCM(10,4)/ 2/, IPSCM(11,4)/ 3/, IPSCM(12,4)/ 2/
     4   , IPSCM(13,4)/ 3/, IPSCM(14,4)/ 2/, IPSCM(15,4)/ 2/
     5   , IPSCM(16,4)/ 2/, IPSCM(17,4)/ 2/
C        CASE 5  THE PROVIDENCE PLANT
      DATA IPSCM( 1,5)/ 9/, IPSCM( 2,5)/10/, IPSCM( 3,5)/10/
     1   , IPSCM( 4,5)/10/, IPSCM( 5,5)/10/, IPSCM( 6,5)/10/
     2   , IPSCM( 7,5)/10/, IPSCM( 8,5)/10/, IPSCM( 9,5)/10/
     3   , IPSCM(10,5)/10/, IPSCM(11,5)/ 4/, IPSCM(12,5)/10/
     4   , IPSCM(13,5)/ 3/, IPSCM(14,5)/10/, IPSCM(15,5)/10/
     5   , IPSCM(16,5)/10/, IPSCM(17,5)/10/
```

```
1020  FORMAT (I1)
1040  FORMAT (20X,'SENSITIVITY ANALYSIS'/25X'CASE ',I1)
6610  FORMAT (/' TREATMENT SCHEME NUMBER = 'I3)
6630  FORMAT (' BASE VALUE OF ',F5.2, ' = 100 PERCENT')
6650    FORMAT (1X,A4,A2,'   25    50   100   150   200   PERCENT OF BAS
     1E VALUE')
6710  FORMAT (5X,A1,2X,5(F4.0,2X),' BASE COST = ',F4.1,' CENTS/KGAL')
C
C        **********************************************************
C        ****************                          ****************
C        ****************    START EXECUTION       ****************
C        ****************                          ****************
C        **********************************************************
C
1000  CONTINUE
C
C          READ IN CASE NUMBER AND WRITE TITLE ONTO PRINTOUT FILE
      READ (5,1020) ICASE
      WRITE (8,1040) ICASE
C
C          READ IN COMPLETE DESCRIPTION OF THE COMMUNITY, SEWAGE, AND
C          TREATMENT PLANT
      CALL SYSTEM
C
C          READ IN CONTROL STRATEGY
2000  CALL SASTGY
C          THE FOLLOWING LINES ARE NECESSARY BECAUSE OF THE RESTRICTIONS
C          ON EQUIVALENCE STATEMENTS
      PRMTR(1) = ALUMCS
      PRMTR(2) = TPLANT(AMLIFE,1)
      PRMTR(3) = TPLANT(AMRATE,1)
      PRMTR(4) = CNSTRC
      PRMTR(5) = CMR
      PRMTR(6) = CIFCOS
      PRMTR(7) = CTRGUS
      PRMTR(8) = ELECOS
      PRMTR(9) = ENFCST
      PRMTR(10) = ICFRAC
      PRMTR(11) = LIMECS
      PRMTR(12) = MATRLS
      PRMTR(13) = PCKLCS
      PRMTR(14) = PCNTNT
      PRMTR(15) = PINPS
      PRMTR(16) = TRNCST
      PRMTR(17) = GCVFF
C          THE PRECEEDING LINES ARE NECESSARY BECAUSE OF THE RESTRICTIONS
C          ON EQUIVALENCE STATEMENTS
C
C          LOOP THRU EACH PARAMETER FOR THE SENSITIVITY ANALYSIS
      DO 7000 IPRM = 1,MAXPRM
C          SAVE THE BASE VALUE FOR THE PARAMETER
      SAVEP = PRMTR(IPRM)
      DO 6000 IVAL = 1,MAXVAL
      PRMTR(IPRM) = VALUE(IVAL) * SAVEP
C          THE FOLLOWING LINES ARE NEEDED BECAUSE OF THE RESRICTIONS
```

```
C          ON EQUIVALENCE STATEMENTS
      ALUMCS = PRMTR(1)
      ALIFE  = PRMTR(2)
      ARATE  = PRMTR(3)
      CNSTRC = PRMTR(4)
      DHR    = PRMTR(5)
      DIFCOS = PRMTR(6)
      DTRGUS = PRMTR(7)
      ELECCS = PRMTR(8)
      ENFCST = PRMTR(9)
      IDFRAC = PRMTR(10)
      LIMECS = PRMTR(11)
      MATRLS = PRMTR(12)
      PCKLCS = PRMTR(13)
      PCNTNT = PRMTR(14)
      PINPS  = PRMTR(15)
      TRNCST = PRMTR(16)
      GOVFF  = PRMTR(17)
      TPLANT(PVAR,ALUMFS) = ALUMCS
      TPLANT(PVAR,LIMEFS) = LIMECS
      TPLANT(PVAR,PCKLFS) = PCKLCS
      DO 2300 I = 1,MAXP
      TPLANT(AMRATE,I) = ARATE
      TPLANT(AMLIFE,I) = ALIFE
2300  CONTINUE
C          THE PRECEEDING LINES ARE NEEDED BECAUSE OF THE RESTRICTIONS
C          ON EQUIVALENCE STATEMENTS
C
C          THE FOLLOWING LINES ARE NECESSARY BECAUSE THE COST
C          COMPUTATIONS WHICH WERE DONE IN 'DTGLIM' MUST BE DONE
C          HERE AFTER THE PARAMETER VALUES HAVE BEEN CHANGED
C          SKIP OVER THIS IF NO DETERGENT RESTRICTIONS
      IF (PYEAR .EQ. 0.)  GO TO 2900
C
C          CHANGE YEAR OF IMPLEMENTATION TO A TIME PERIOD
      ICTP = (PYEAR - SPCPIN(YEAR,1))/TPSIZE
C
C              IF PRESENT P CONC. IS UNKNOWN, USE ASSUMED VALUE
      IF (PRESPC .LT. 0.)  PRESPC = PDRATC*PPRATO
C
C          COMPUTE INFLUENT PHOSPHORUS RESULTING FROM DETERGENTS IN
C          (POUNDS/DAY)
      POTRG = DTRGUS/365. * PRESPC * SEWPOP(1)
C
C          COMPUTE NEW P CONCENTRATION RESULTING FROM LEGISLATION
      PLEGRT  = (PRESPC - PCNTNT )/PRESPC
      PINNEW = PINPS - POTRG*PLEGRT/(CAVE*8.33)
      IF (PINNEW .LE. 0. .OR. PLTGRT .LT. 0.)  GO TO 2700
C
C          COMPUTE THE ANNUAL PER CAPITA  COST OF NON-PHOSPHATE SUBSTITUTE
      PCOST = (DIFCOS*DTRGUS + ENFCST)*TPSIZE
      IF (PCNTNT .EQ. PRESPC)  PCOST = 0.
C
C          FILL INFLUENT HALF OF IELIMT
C          AND STORE SUBSTITUTION COSTS FOR EACH TIME PERIOD
```

```
      DO 2500 TP = ICTP,MAXTP
      IELIMT(INF,TP) = PINNEW
      PSUBCS(TP) = PCOST * SEWPOP(TP)
2500  CONTINUE
      GO TO 2900
C
C        PUT INVALID NUMBER IN COST ARRAY
2700  CONTINUE
      DO 2750 IM = 1,MAXMES
      COSTS(IM,IVAL) = 999999999.
2750  CONTINUE
      GO TO 6000
2900  CONTINUE
C        THE PRECEEDING LINES ARE NECESSARY BECAUSE THE COST
C        COMPUTATIONS WHICH WERE PERFORMED IN 'DTGLIM' MUST NOW
C        BE DONE AFTER THE PARAMETER VALUE HAS CHANGED.
C
C        TURN ON THE LIQUID TREATMENT SCHEME WHICH IS THE LOWEST
C        COST SCHEME FOR THIS PARAMETER (SCHEME IS KNOWN
C        FROM PREVIOUS RUNS OF 'REMOVE') AND CASE
      ELGBTY(IPSCM(IPRM,ICASE)) = ON
C
C        COMPUTE COSTS FOR ALL ELIGIBLE SCHEMES
      ISCHM = IPSCM(IPRM,ICASE)
C        ADD ALTERNATIVE LIQUID HANDLING EQUIPMENT
3000  CALL SALCHS
C
C        COMPUTE LIQUID AND SLUDGE COSTS OF THIS ELIGIBLE TREATMENT
C        SCHEME FOR ALL TIME PERIODS
      CALL TPTPNT
C
C        COMPUTE COST OF SELECTED SOLID SINKS OVER ALL TIME
      CALL SSKCST
C
C        COMPUTE A SUMMARY OF COSTS FOR THIS TREATMENT SCHEME
      CALL SARPRT
C
6000  CONTINUE
C        RESTORE PARAMETER TO BASE VALUE
      PRMTR(IPRM) = SAVEP
C        THE FOLLOWING LINES ARE NEEDED BECAUSE OF THE RESRICTIONS
C        ON EQUIVALENCE STATEMENTS
      ALUMCS = PRMTR(1)
      ALIFE  = PRMTR(2)
      ARATE  = PRMTR(3)
      CNSTRC = PRMTR(4)
      DHR    = PRMTR(5)
      DIFCOS = PRMTR(6)
      DTRGUS = PRMTR(7)
      ELECOS = PRMTR(8)
      ENECST = PRMTR(9)
      IDFRAC = PRMTR(10)
      LIMECS = PRMTR(11)
      MATRLS = PRMTR(12)
      PCKLCS = PRMTR(13)
      PCNTNT = PRMTR(14)
      PINPS  = PRMTR(15)
      TRNCST = PRMTR(16)
      GOVRF  = PRMTR(17)
      TPLANT(PVAR,ALUMFS) = ALUMCS
      TPLANT(PVAR,LIMEFS) = LIMECS
      TPLANT(PVAR,PCKLFS) = PCKLCS
      DO 6300 I = 1,MAXP
      TPLANT(AMRATE,I) = ARATE
      TPLANT(AMLIFE,I) = ALIFE
6300  CONTINUE
C        THE PRECEEDING LINES ARE NEEDED BECAUSE OF THE RESTRICTIONS
C        ON EQUIVALENCE STATEMENTS
C
C        COMPUTE AND WRITE PERCENTAGE COSTS
      DO 6500 IM = 1,MAXMES
      DO 6400 IV = 1,MAXVAL
C        CONVERT CENTS/KGAL TO PERCENTAGE CHANGE
      IF (COSTS(IM,IHUN) .LE. .00000001)  GO TO 6350
      PERCNT(IM,IV) = COSTS(IM,IV)/COSTS(IM,IHUN) * 100.
      GO TO 6400
6350  CONTINUE
      PERCNT(IM,IV) = 100.
6400  CONTINUE
6500  CONTINUE
      WRITE (8,6610) ISCHM
      WRITE (8,6630) PRMTR(IPRM)
      WRITE (8,6650) (PRINTN(IPRM,I),I=1,2)
      DO 6800 IM = 1,MAXMES
      WRITE (8,6710) PRINTM(IM), (PERCNT(IM,IV), IV=1,MAXVAL)
     1 , COSTS(IM,IHUN)
6800  CONTINUE
7000  CONTINUE
C
C        END OF PROGRAM SARMVE
      CALL EXIT
      END
      SUBROUTINE SARPRT
C
C        PURPOSE:
C           SARPRT COMPUTES A SUMMARY OF THE UNIT COSTS ASSOCIATED WITH
C           THE TREATMENT SCHEME.
C
C        COMMON BLOCKS:
C           DTRGNT - DETERGENT INFORMATION
C           LBRCST - COST OF LABOR
C           LIQUID - INFO. ABOUT LIQUID INFLUENT
C           PRGCNT - CONTAINS PROGRAM CONTROL VARIABLES
C           PRNTR  - CONTAINS PRINTOUT CONTROL VARIABLES
C           SACOM  - CONTAINS SENSITIVITY ANALYSIS VARIABLES
C           SCHEME - INFO ABOUT LIQUID TREATMENT SCHEMES
C           SEWPOP - THE SEWERED POPULATION
C           SLCHAR - SLUDGE, LIQUID CHARACTERISTICS
C           SLUDGE - SLUDGE INFO
C           SSINK  - SOLID SINK INFORMATION
C           TIME   - PARAMETERS OF TIME HORIZON
C           TPLANT - CHARACTERISTICS OF TREATMENT PROCESSES
C           TRTCST - TREATMENT COSTS
C
C        CALLED BY:
C           SARMVE - THE MAIN SENSITIVITY ANALYSIS PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES   15 MAR 73
C
C        ---------------------------------------------------------------
C
      COMMON /DTRGNT/ DTRGUS, PCRATO, PPRATO, DIFCOS, PRESPC
     1               , PDTRG , ENFCST,  PSUBCS(20), PCNTNT

      REAL LEGPC
      COMMON /LBRCST/ DHR, IOFRAC, GOVFF

      REAL IOFRAC

      COMMON /LIQUID/ ALKIPS, BODIPS, MLSSAR, NH3IAR, PINPS, QAVE
     1                , QPEAK, SSINPS, TBODAR

      REAL MLSSAR, NH3IAR

      COMMON /PRGCNT/ IGOTO, IANSWR, FIXED, FLOTE, ALPHA
     1 , YES, NO, ON, OFF
     2 , ISCHM
     3 , IDUMMY, DUMMY

      EQUIVALENCE (IANSWR,ANSWER)

      INTEGER FIXED, FLOTE, ALPHA
      INTEGER YES, ON, OFF

      COMMON /PRNTR/ ISHORT, ISUPER, ISKIP, IPASS, ISELCT(5)
      COMMON /SACCM/ COSTS(6,5), IVAL, PYEAR

      COMMON /SCHEME/ SCHEME(25,25), ELGBTY(25), MINEFP(25), MAXSCM
     1 , ALPYPS, FCPYPS, FCLMPS, LIMEPS, ALPYFB, FCPYFB, FCLMFB, LIMEFB
     2 , ALUMAB, FECLAB, NAALAB, ALABMF, FCABMF, NAABMF, ALUMTF, FECLTF
     3 , ALTFMF, FCTFMF, ALFBAS, FCFBAS, L1FBAS, L2FBAS, NONE
     4 , EQUIP(45)

      INTEGER ELGBTY, EQUIP, SCHEME
      INTEGER ALPYPS, FCPYPS, FCLMPS, ALPYFB, FCPYFB, FCLMFB, ALUMAB
     1 , FECLAB, ALABMF, FCABMF, ALUMTF, FECLTF, ALTFMF, FCTFMF, ALFBAS
     2 , FCFBAS
      REAL MINEFP

      COMMON /SEWPOP/ FNCTYP, SPOPIN(2,5), SEWPOP(20)
     1 , YEAR, SPOP, MAXPV

      INTEGER YEAR, SPOP, FNCTYP

      COMMON /SLCHAR/    ADDSSR, ALKIAR, FCVFD , LBNVPS, LBNVSS
     1 , LBNVTS, LBVPS , LBVSS , LBVTS , LIMEPD, LMVFD , PALUM
     2 , PCO2  , PFECL , PNAAL , PNAOH , PCLYC , PPCKL , QPSLGE
     3 , QSSLGE, CTOTAL, QTSLGE, SRCAT , SRLIME, TLBNVS, TLBPS
     4 , TLBSLG, TLBSS , TLBTS , TLBVS , WOLBSS, WOPALM, WOPCO2
     5 , WOPFC , WOPLIM, WOPNAL, WOPNCH, WOPPLY, WOPPCK, WRCAT
     6 , PLIME , PYFTD , PYVFD , PPOLY , SRALF , SRCATA, WRALF
     7 , SRFEF , WRFEF , SRFEP , SRALP , WRALP , WRFEP , WRALA
     8 , WRFEA , AARATO, FERATO, SRCATS, WRCATS, WRALS , WRFES
     9 , CO2D  , SRTLIM, TSETUD, LIMETD, BODIAR, WOTLBS

      REAL       LBNVPS, LBNVSS, LBNVTS, LBVPS , LBVSS , LBVTS
     1 , LIMEPD, LMVFD , LIMETD

      COMMON /SLUDGE/ ASD   , FLCTUD, GRAVUD, HPDFT , HPDVF , PSETUD
     1                , PSRMVE, VFPSLG, VSANRM, VSARM

      COMMON /SSINK/ TRNCST, SWASTE(20), SCLSNK(2,15), SSCOST(20)
     1               , BESTSS(20), CAP, DIST, MAXSS
      INTEGER BESTSS, CAP, DIST

      COMMON /TIME/ NOYRS, MAXTP, TPSIZE, TP

      INTEGER TP

      COMMON /TPLANT/ TPLANT(16,45)
     1 , RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN, DIFAIR
     2 , MCHAER, FLCCCP, SECSET, RE1PMP, CLFEED, CLBASN, MULFTR
     3 , RE2PMP, GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK
     4 , VACFTR, CENFUG, MHINC , FBINC , WSPOND, SLGOON, RECRB1
     5 , RECRB2, TERST1, TERST2, ALUMFS, FECLFS, LIMEFS, PCLYFS
     6 , CO2FS , NAALFS, PCKLFS, NAOHFS, RECALC, FLOCCT
     7 , PNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
     8 , WVAR  , BPARM , BASE  , APVAR , PARMX , MINRV , MAXRV
     9 , MAXP
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```
       INTEGER RWPUMP, PRETRT, PRMSET, PSPUMP, TRKFTR, AERBSN
      1 , DIFAIR, FLOCCP, SECSET, RCIPMP, CLFEED, CLRASN, REZPMP
      2 , GRVTKN, FLOTKN, ANADIG, AERDIG, DRYBED, SLDTNK, VACFTR
      3 , CENFUC, FBINC , WSPOND, SLGCON, RECRB1, RECRB2, TERST1
      4 , TERST2, ALUMFS, FECLFS, POLYFS, CO2FS , PCKLFS, RECALC
      5 , FNAME , AMRATE, AMLIFE, PPARM , PVAR  , WOPARM, WPARM
      6 , WVAR  , BPARM , FLOCCT, BASE  , APVAR , PARMX

       COMMON /TRTCST/ OMHRS(45,20), MMHRS(45,20), THS(45,20), CONCOS(45)
      1               , AMCOST(45), TPFADD(45)

       REAL MMHRS
       INTEGER TPFADD

C         ------------END OF COMMON BLOCKS
       DIMENSION LBRAVE(45), SPAVE(45)
       REAL LBRAVE

       DATA MSRA/1/, MSPL/2/, MSRM/3/, MSRP/4/, MSPS/5/, MSPT/6/


C         ****************************************************************
C         ****************                                ****************
C         ****************    START EXECUTION             ****************
C         ****************                                ****************
C         ****************************************************************
C
1000   CONTINUE
2100   CONTINUE
C
C         COMPUTE CONSTRUCTION COSTS
       TOTCON = 0.
       TOTAMC = 0.
       DO 2900 IPROC = 1,MAXP
       IF (EQUIP(IPROC) .EQ. OFF)  GO TO 2900
       TOTCON = TOTCON + CONCOS(IPROC)
       TOTAMC = TOTAMC + AMCOST(IPROC)
       YPFADD = TPFADD(IPROC)*TPSIZE + SPOPIN(YEAR,1)
2900   CONTINUE
3000   CONTINUE
C
C         COMPUTE PERIODIC OPERATING COSTS
C
C         ZERO COLUMN TOTALS
3100   CONTINUE
       CTOPAV = 0.
       CTOPMX = 0.
       CTOPMN = 0.
       CTAMAV = 0.
       CTAMMX = 0.
       CTAMMN = 0.
       CTSPAV = 0.
       CTSPMX = 0.
       CTSPMN = 0.
       CTLBAV = 0.
      CTAVRT = 0.
      DO 3900 IPROC = 1,MAXP
      IF (EQUIP(IPROC) .EQ. OFF)  GO TO 3900
      OP = 0.
      UP = 0.
      OPMAX = -1.
      OPMIN = 1.E10
      AM = 0.
      AMMAX = -1.
      AMMIN = 1.E10
      SP = 0.
      SPMAX = -1.
      SPMIN = 1.E10
C
C         TOTAL UP MAN-HOURS AND COSTS
      DO 3800 TP = 1,MAXTP
      OP = OP + AMAX1(OMHRS(IPROC,TP),0.)
      AM = AM + AMAX1(MMHRS(IPROC,TP),0.)
      SP = SP + AMAX1(TMS  (IPROC,TP),0.)
      OPMAX = AMAX1(OPMAX,OMHRS(IPROC,TP))
      AMMAX = AMAX1(AMMAX,MMHRS(IPROC,TP))
      SPMAX = AMAX1(SPMAX,TMS  (IPROC,TP))
      OPMIN = AMIN1(OPMIN,OMHRS(IPROC,TP))
      AMMIN = AMIN1(AMMIN,MMHRS(IPROC,TP))
      SPMIN = AMIN1(SPMIN,TMS  (IPROC,TP))
3800  CONTINUE
C
C         COMPUTE AVERAGE PERIODIC COSTS
      OPAVE = OP/MAXTP
      AMAVE = AM/MAXTP
      SPAVE(IPROC) = SP/MAXTP
      LBRAVE(IPROC) = ((OPAVE+AMAVE)*CHR*(1.+IDFRAC))/1000.
      ROWTOT = LBRAVE(IPROC) + SPAVE(IPROC)/1000.
C
C         COMPUTE COLUMN TOTALS
      CTOPAV = CTOPAV + OPAVE
      CTOPMX = CTOPMX + OPMAX
      CTOPMN = CTOPMN + OPMIN
      CTAMAV = CTAMAV + AMAVE
      CTAMMX = CTAMMX + AMMAX
      CTAMMN = CTAMMN + AMMIN
      CTSPAV = CTSPAV + SPAVE(IPROC)
      CTSPMX = CTSPMX + SPMAX
      CTSPMN = CTSPMN + SPMIN
      CTLBAV = CTLBAV + LBRAVE(IPROC)
      CTAVRT = CTAVRT + ROWTOT
3900  CONTINUE
4000  CONTINUE
C
C         COMPUTE UNIT COSTS
4100  CONTINUE
      TPOP = 0.
      DO 4300 TP = 1,MAXTP
      TPOP = TPOP + SEWPCP(TP)
4300  CONTINUE
```

```
      POPAVE = TPOP/MAXTP
      FLWAVE = (QAVE*POPAVE/SEWPOP(1))*1000.
      CTUAMC = 0.
      CTULBR = 0.
      CTUMSP = 0.
      CTRT = 0.
      DO 4900 IPROC = 1,MAXP
      IF (EQUIP(IPROC) .EQ. OFF)  GO TO 4900
      A = 0.
      DO 4800 TP = 1,MAXTP
      IF (TP .GE. TPFADD(IPROC)) A = A + AMCOST(IPROC)
4800  CONTINUE
      A = A/MAXTP
      UAMC = ((A*1000./(365.*TPSIZE))/FLWAVE)*100.
      ULBR = ((LBRAVE(IPROC)*1000./(365.*TPSIZE))/FLWAVE)*100.
      UMSP = ((SPAVE(IPROC)/(365.*TPSIZE))/FLWAVE)*100.
      ROWTOT = UAMC + ULBR + UMSP
      CTUAMC = CTUAMC + UAMC
      CTULBR = CTULBR + ULBR
      CTUMSP = CTUMSP + UMSP
      CTRT = CTRT + ROWTOT
4900  CONTINUE
5000  CONTINUE
C
C         COMPUTE COSTS OF SUBTITUTES FOR PHOSPHATE DETERGENTS
      P = 0.
      PMAX = -1.
      PMIN = 1.E10
      DO 5500 TP = 1,MAXTP
      P = P + PSUBCS(TP)
      PMAX = AMAX1(PMAX,PSUBCS(TP))
      PMIN = MIN1(PMIN,PSUBCS(TP))
5500  CONTINUE
      IF (P .LE. 0.)  GO TO 5900
      PAVE = P/MAXTP
      UP = ((PAVE/(365.*TPSIZE))/FLWAVE)*100.
5900  CONTINUE
C
6000  CONTINUE
C
C         COMPUTE COSTS OF SOLID SINKS
6100  CONTINUE
      CTSSCS = 0.
      CTSWST = 0.
      DO 6500 TP = 1,MAXTP
C         USE 1. INSTEAD OF 0. BECAUSE OF ROUND-OFF
      IF (SWASTE(TP) .LE. 1.)  GO TO 6500
      CTSSCS = CTSSCS + SSCOST(TP)
      CTSWST = CTSWST + SWASTE(TP)
6500  CONTINUE
      USSCS = CTSSCS/((TPOP/SEWPOP(1))*QAVE*1000.*365.*TPSIZE)*100.
6900  CONTINUE
C
C         COMPUTE SINGLE NUMBER FOR SUPER SHORT PRINTOUT
7000  CONTINUE
```

```
      TOTAL = CTRT + UP + USSCS
 7900 CONTINUE
C
C         PUT UNIT COSTS INTO A COST ARRAY FOR USE BY 'SARMVE'
      COSTS(MSRA,IVAL) = CTUAMC
      COSTS(MSRL,IVAL) = CTULBR
      COSTS(MSRM,IVAL) = CTUMSP
      COSTS(MSRP,IVAL) = UP
      COSTS(MSRS,IVAL) = USSCS
      COSTS(MSRT,IVAL) = TOTAL
C
C         END OF SUBROUTINE REPORT
 9000 CONTINUE
      RETURN
      END
      SUBROUTINE SASTGY
C
C        PURPOSE:
C           SASTGY CALLS THE SUBROUTINES WHICH READ IN VALUES FOR
C           THE VARIABLES OF THE DESIRED CONTROL STRATEGY.
C           THESE VARIABLES ARE IN THE CATEGORIES OF: TIME, EFFLUENT
C           LIMITS, DETERGENT RESTRICTIONS, AND INDUSTRIAL CONTROLS.
C
C        SUBROUTINES CALLED:
C           SADGLM  - READS IN RESTRICTIONS ON DETERGENT PHOSPHATES
C           EFFLIM  - READS IN RESTRICTIONS ON TREATMENT PLANT EFFLUENT
C           INDLIM  - READS IN RESTRICTIONS ON INDUSTRIAL EFFLUENTS
C           INTIME  - READS IN DESCRIPTION OF TIME HORIZON
C
C        CALLED BY:
C           REMOVE  - THE MAIN PROGRAM
C
C        AUTHOR:
C           DAVID A BARNES   06OCT72
C
C        ---------------------------------------------------------------

C        ***************************************************************
C        ****************                               ****************
C        ****************    START EXECUTION            ****************
C        ****************                               ****************
C        ***************************************************************
C
C        READ IN DESCRIPTION OF TIME HORIZON
      CALL INTIME
C
C        READ IN PHOSPHORUS EFFLUENT RESTRICTIONS
      CALL EFFLIM
C
C        READ IN RESTRICTIONS ON PHOSPHATES IN DETERGENTS
      CALL SADGLM
C
C        READ IN RESTRICTIONS ON INDUSTRIAL PHOSPHORUS EFFLUENTS
      CALL INDLIM
C
C        END OF SUBROUTINE SASTGY
      RETURN
      END
```

```
                    SENSITIVITY ANALYSIS
                           CASE 1

TREATMENT SCHEME NUMBER =    9
BASE VALUE OF  0.03 = 100 PERCENT
ALUMCS    25      50     100     150     200      PERCENT OF BASE VALUE
     A  100.    100.    100.    100.    100.     BASE COST =   0.8 CENTS/KGAL
     L  100.    100.    100.    100.    100.     BASE COST =   1.9 CENTS/KGAL
     M   32.     55.    100.    145.    190.     BASE COST =   4.6 CENTS/KGAL
     P  100.    100.    100.    100.    100.     BASE COST =   2.1 CENTS/KGAL
     S  100.    100.    100.    100.    100.     BASE COST =   1.1 CENTS/KGAL
     T   70.     80.    100.    120.    140.     BASE COST =  10.5 CENTS/KGAL

TREATMENT SCHEME NUMBER =   10
BASE VALUE OF 20.00 = 100 PERCENT
AMLIFE    25      50     100     150     200      PERCENT OF BASE VALUE
     A  288.    161.    100.     81.     73.     BASE COST =   0.8 CENTS/KGAL
     L  100.    100.    100.    100.    100.     BASE COST =   1.4 CENTS/KGAL
     M  100.    100.    100.    100.    100.     BASE COST =   2.2 CENTS/KGAL
     P  100.    100.    100.    100.    100.     BASE COST =   2.1 CENTS/KGAL
     S  100.    100.    100.    100.    100.     BASE COST =   1.1 CENTS/KGAL
     T  119.    106.    100.     98.     97.     BASE COST =   7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =   10
BASE VALUE OF  0.05 = 100 PERCENT
AMRATE    25      50     100     150     200      PERCENT OF BASE VALUE
     A   71.     80.    100.    122.    146.     BASE COST =   0.8 CENTS/KGAL
     L  100.    100.    100.    100.    100.     BASE COST =   1.4 CENTS/KGAL
     M  100.    100.    100.    100.    100.     BASE COST =   2.2 CENTS/KGAL
     P  100.    100.    100.    100.    100.     BASE COST =   2.1 CENTS/KGAL
     S  100.    100.    100.    100.    100.     BASE COST =   1.1 CENTS/KGAL
     T   97.     98.    100.    102.    105.     BASE COST =   7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =   10
BASE VALUE OF  1.71 = 100 PERCENT
CNSTRC    25      50     100     150     200      PERCENT OF BASE VALUE
     A   25.     50.    100.    150.    200.     BASE COST =   0.8 CENTS/KGAL
     L  100.    100.    100.    100.    100.     BASE COST =   1.4 CENTS/KGAL
     M  100.    100.    100.    100.    100.     BASE COST =   2.2 CENTS/KGAL
     P  100.    100.    100.    100.    100.     BASE COST =   2.1 CENTS/KGAL
     S  100.    100.    100.    100.    100.     BASE COST =   1.1 CENTS/KGAL
     T   92.     95.    100.    105.    110.     BASE COST =   7.6 CENTS/KGAL
```

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TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  4.10 = 100 PERCENT
CHP        25     50     100    150    200    PERCENT OF BASE VALUE
     A  100.   100.   100.   100.   100.    BASE COST =  0.8 CENTS/KGAL
     L   25.    50.   100.   150.   200.    BASE COST =  1.4 CENTS/KGAL
     M  100.   100.   100.   100.   100.    BASE COST =  2.2 CENTS/KGAL
     P  100.   100.   100.   100.   100.    BASE COST =  2.1 CENTS/KGAL
     S  100.   100.   100.   100.   100.    BASE COST =  1.1 CENTS/KGAL
     T   86.    91.   100.   109.   119.    BASE COST =  7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  0.02 = 100 PERCENT

DIECOS     25     50     100    150    200    PERCENT OF BASE VALUE
     A  100.   100.   100.   100.   100.    BASE COST =  0.8 CENTS/KGAL
     L  100.   100.   100.   100.   100.    BASE COST =  1.4 CENTS/KGAL
     M  100.   100.   100.   100.   100.    BASE COST =  2.2 CENTS/KGAL
     P   67.    78.   100.   122.   144.    BASE COST =  2.1 CENTS/KGAL
     S  100.   100.   100.   100.   100.    BASE COST =  1.1 CENTS/KGAL
     T   91.    94.   100.   106.   112.    BASE COST =  7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =  10
BASE VALUE OF 16.00 = 100 PERCENT
CTRCUS     25     50     100    150    200    PERCENT OF BASE VALUE
     A  101.   101.   100.    99.    98.    BASE COST =  0.8 CENTS/KGAL
     L  110.   107.   100.    93.    85.    BASE COST =  1.4 CENTS/KGAL
     M  128.   119.   100.    81.    63.    BASE COST =  2.2 CENTS/KGAL
     P   67.    78.   100.   122.   144.    BASE COST =  2.1 CENTS/KGAL
     S  129.   120.   100.    80.    61.    BASE COST =  1.1 CENTS/KGAL
     T  105.   103.   100.    96.    93.    BASE COST =  7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  0.02 = 100 PERCENT
ELECOS     25     50     100    150    200    PERCENT OF BASE VALUE
     A  100.   100.   100.   100.   100.    BASE COST =  0.8 CENTS/KGAL
     L  100.   100.   100.   100.   100.    BASE COST =  1.4 CENTS/KGAL
     M  100.   100.   100.   100.   100.    BASE COST =  2.2 CENTS/KGAL
     P  100.   100.   100.   100.   100.    BASE COST =  2.1 CENTS/KGAL
     S  100.   100.   100.   100.   100.    BASE COST =  1.1 CENTS/KGAL
     T  100.   100.   100.   100.   100.    BASE COST =  7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  0.40 = 100 PERCENT
ENECST     25     50     100    150    200    PERCENT OF BASE VALUE
     A  100.   100.   100.   100.   100.    BASE COST =  0.8 CENTS/KGAL
     L  100.   100.   100.   100.   100.    BASE COST =  1.4 CENTS/KGAL
     M  100.   100.   100.   100.   100.    BASE COST =  2.2 CENTS/KGAL
     P   58.    72.   100.   128.   156.    BASE COST =  2.1 CENTS/KGAL
     S  100.   100.   100.   100.   100.    BASE COST =  1.1 CENTS/KGAL
     T   89.    92.   100.   108.   115.    BASE COST =  7.6 CENTS/KGAL
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TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  0.15 = 100 PERCENT
IDFRAC    25     50    100    150    200    PERCENT OF BASE VALUE
    A  100.  100.  100.  100.  100.    BASE COST =  0.8 CENTS/KGAL
    L   90.   93.  100.  107.  113.    BASE COST =  1.4 CENTS/KGAL
    M  100.  100.  100.  100.  100.    BASE COST =  2.2 CENTS/KGAL
    P  100.  100.  100.  100.  100.    BASE COST =  2.1 CENTS/KGAL
    S  100.  100.  100.  100.  100.    BASE COST =  1.1 CENTS/KGAL
    T   98.   99.  100.  101.  102.    BASE COST =  7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =   4
BASE VALUE OF  0.02 = 100 PERCENT
LIMECS    25     50    100    150    200    PERCENT OF BASE VALUE
    A  100.  100.  100.  100.  100.    BASE COST =  0.6 CENTS/KGAL
    L  100.  100.  100.  100.  100.    BASE COST =  3.3 CENTS/KGAL
    M   45.   64.  100.  136.  173.    BASE COST =  3.7 CENTS/KGAL
    P  100.  100.  100.  100.  100.    BASE COST =  2.1 CENTS/KGAL
    S  100.  100.  100.  100.  100.    BASE COST =  8.2 CENTS/KGAL
    T   89.   92.  100.  108.  115.    BASE COST = 17.9 CENTS/KGAL

TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  1.18 = 100 PERCENT
MATELS    25     50    100    150    200    PERCENT OF BASE VALUE
    A  100.  100.  100.  100.  100.    BASE COST =  0.8 CENTS/KGAL
    L  100.  100.  100.  100.  100.    BASE COST =  1.4 CENTS/KGAL
    M   25.   50.  100.  150.  200.    BASE COST =  2.2 CENTS/KGAL
    P  100.  100.  100.  100.  100.    BASE COST =  2.1 CENTS/KGAL
    S  100.  100.  100.  100.  100.    BASE COST =  1.1 CENTS/KGAL
    T   79.   86.  100.  114.  128.    BASE COST =  7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =   3
BASE VALUE OF  0.04 = 100 PERCENT
PCKLCS    25     50    100    150    200    PERCENT OF BASE VALUE
    A  100.  100.  100.  100.  100.    BASE COST =  2.6 CENTS/KGAL
    L  100.  100.  100.  100.  100.    BASE COST =  4.2 CENTS/KGAL
    M   75.   83.  100.  117.  134.    BASE COST =  5.2 CENTS/KGAL
    P  100.  100.  100.  100.  100.    BASE COST =  2.1 CENTS/KGAL
    S  100.  100.  100.  100.  100.    BASE COST = 10.0 CENTS/KGAL
    T   95.   96.  100.  104.  107.    BASE COST = 24.2 CENTS/KGAL

TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  0.05 = 100 PERCENT
PCNTNT    25     50    100    150    200    PERCENT OF BASE VALUE
    A   99.   99.  100.  101.  102.    BASE COST =  0.8 CENTS/KGAL
    L   83.   93.  100.  107.  114.    BASE COST =  1.4 CENTS/KGAL
    M   72.   81.  100.  119.  137.    BASE COST =  2.2 CENTS/KGAL
    P  100.  100.  100.  100.    0.    BASE COST =  2.1 CENTS/KGAL
    S   71.   80.  100.  120.  139.    BASE COST =  1.1 CENTS/KGAL
    T   86.   90.  100.  110.   92.    BASE COST =  7.6 CENTS/KGAL
```

```
TREATMENT SCHEME NUMBER =  10
BASE VALUE OF 10.00 = 100 PERCENT
PINPS     25     50    100    150    200   PERCENT OF BASE VALUE
    A   ****    55.   100.   103.   105.   BASE COST =  0.8 CENTS/KGAL
    L   ****    72.   100.   124.   146.   BASE COST =  1.4 CENTS/KGAL
    M   ****    33.   100.   166.   233.   BASE COST =  2.2 CENTS/KGAL
    P   ****   100.   100.   100.   100.   BASE COST =  2.1 CENTS/KGAL
    S   ****    30.   100.   170.   239.   BASE COST =  1.1 CENTS/KGAL
    T   ****    61.   100.   134.   168.   BASE COST =  7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  5.00 = 100 PERCENT
TRNCST    25     50    100    150    200   PERCENT OF BASE VALUE
    A  100.   100.   100.   100.   100.    BASE COST =  0.8 CENTS/KGAL
    L  100.   100.   100.   100.   100.    BASE COST =  1.4 CENTS/KGAL
    M  100.   100.   100.   100.   100.    BASE COST =  2.2 CENTS/KGAL
    P  100.   100.   100.   100.   100.    BASE COST =  2.1 CENTS/KGAL
    S   25.    50.   100.   150.   200.    BASE COST =  1.1 CENTS/KGAL
    T   89.    93.   100.   107.   115.    BASE COST =  7.6 CENTS/KGAL

TREATMENT SCHEME NUMBER =  10
BASE VALUE OF  0.50 = 100 PERCENT
GCVFF     25     50    100    150    200   PERCENT OF BASE VALUE
    A  175.   150.   100.    50.     0.    BASE COST =  0.8 CENTS/KGAL
    L  100.   100.   100.   100.   100.    BASE COST =  1.4 CENTS/KGAL
    M  100.   100.   100.   100.   100.    BASE COST =  2.2 CENTS/KGAL
    P  100.   100.   100.   100.   100.    BASE COST =  2.1 CENTS/KGAL
    S  100.   100.   100.   100.   100.    BASE COST =  1.1 CENTS/KGAL
    T  108.   105.   100.    95.    90.    BASE COST =  7.6 CENTS/KGAL
```

SECTION VI

ACKNOWLEDGEMENTS

The support and assistance of the Project Officer, Mr. D. King Boynton, Jr. of the Office of Air and Water Programs, Environmental Protection Agency, is acknowledged with sincere thanks.

The authors also wish to thank Ms. Paula Craig for her meticulous preparation of this report.

SECTION VII

REFERENCES

1. "Estimating Costs and Manpower Requirements for Conventional Wastewater Treatment Facilities," Black and Veatch, Inc., EPA Report No. 17090 DAN (1971).

2. A Computer Model for Evaluating Local Phosphorus Removal Strategies, Yeaple, D. S., Barnes, D. A., DiGiani, F. A., EPA Report (In Press).

SECTION VIII

APPENDICES

The appendix for each case study contains the input data to the program SARMVE and the treatment plant surveys from which the program input was prepared. There is no survey form for Case 3 because this 5 MGD trickling plant was designed on a theoretical basis using the program REMOVE.

APPENDIX A

GENERAL - Case 1 - Marlboro, Mass.

DATE 28 MAR 73
YOUR NAME Charlie Keyser
TITLE Operator
PHONE 617 481 1208
Name of treatment plant Westerly Treatment Plant
Street Boundary Rd
City Marlboro
State & ZIP MA 01752

COMMUNITY

What is the present sewered population served by this plant? 16 000

Do you have quantitative knowledge of the future sewered population? YES___ NO ✓

If the answer to the above question was YES, then please give the future population values and their corresponding years.

SEWERED POP.	YEAR

What is the average direct hourly labor rate for all employees? 4.10 $/Hour

What are the indirect labor costs expressed as a fraction of direct labor costs? ________ (fraction)

What is the average cost of electricity? _______ $/KWHr

Do you dispose of sewage sludge on land? YES ✓ NO___

If the answer to above is YES, then please give the capacity and the distance from the plant to the landfill site for each available landfill site.

CAPACITY (tons)	DISTANCE (miles)
infinite	2

________________ ________________
________________ ________________
________________ ________________
________________ ________________
________________ ________________
________________ ________________
________________ ________________
________________ ________________
________________ ________________
________________ ________________

What is the average sost of transporting 1 ton of dry sludge 1 mile to a landfill site? ________$

What phosphorus effluent level would you like to achieve? ________mg/l

What (if any) is the present legislated limit on phosphorus content in detergents? ________% Phosphorus

What (if any) are the proposed detergent phosphorus limits and their years of implementation?

% P	YEAR
___	____
___	____
___	____
___	____
___	____

If there are (or will be) limits on detergent phosphorus, what is the cost of enforcing these limits? ________$/capita/year

SEWAGE

What is the average flow into your treatment plant? ___1.5___MGD

What is the peak diurnal flow? ___2.4___MGD

What is the phosphorus concentration into the primary settler? ________mg/l

What is the BOD5 concentration into the primary settler? ___350___mg/l

What is the suspended solids concentration into the primary

settler? 325 mg/l

What is the alkalinity concentration into the primary settler? ________mg CaCO3/l

If your plant has an aeration process (activated sludge or trickling filter):

What is the mixed liquor suspended solids concentration into the aeration process? 2600 mg/l

What is the NH3 concentration into the aeration process? ________mg/l

What is the total change in BOD5 (i.e., the fraction removed) across the aeration process? ________(fraction removed)

TREATMENT PLANT

The following questions concern the individual treatment processes. If you do not have a particular process in your treatment plant or you do not know a particular value desired, then please leave the answer space blank. If there are multiple pieces of equipment operating in parallel for a particular process their sizes should be summed together for this questionnaire. Note: A number in parantheses following a process name refers to a process operating in series in relation to the other process of the same name.

RAW WASTE PUMPING
Initial firm capacity 2.5 MGD

PRE TREATMENT
Maximum capacity 2.5 MGD

FLOCCULATION BASIN BEFORE PRIMARY
Maximum capacity ________MGD

PRIMARY SETTLER
Surface area of the settler 3.18 Thos. sq. ft.
Design overflow rate 315 gpd/sq. ft.
Underflow sludge density ________%
Per cent removal of suspended solids ________%
Voltatile fraction of primary sludge ________fraction

PRIMARY SLUDGE PUMPING

Initial firm capacity 110 gpm
Operating hours 8 hr/day

TRICKLING FILTER

Media volume ________ Thos. cu. ft.
Filter depth ________ feet
Hydraulic loading ________ MGD/acre

AERATION BASIN

Liquid volume 97.2 Thos. cu. ft.
Detention time 17.4 Hours
Activated sludge density ________ %

DIFFUSED AIR SYSTEM

Initial firm blower capacity ________ Thos. cfm
Diffuser efficiency ________ fraction

MECHANICAL AERATION

Total install capacity 120 Hp
Transfer efficiency 1.86 lbs O2/hp-hr

SECONDARY SETTLER

Surface area of the settler 2.51 Thos. sq. ft.
Design overflow rate 398 gpd/sq. ft.

RECIRCULATION PUMPING (1)

Maximum capacity 2.5 MGD

CHLORINATION FEEDING SYSTEM

Average chlorine use 33 lbs/day
Chlorine dosage 8 mg/l

CHLORINATION CONTACT BASIN

Liquid volume 5.6 Thos. cu. ft.
Chlorine contact time 30 minutes

MULTI-MEDIA FILTER

Capacity ________ MGD

RECIRCULATION PUMPING (2)

Maximum capacity ________ MGD

FLOCCULATION BASIN BEFORE TERTIARY

Maximum capacity ________ MGD

RECARBONINATION BASIN (1)

Liquid volume ________ Thos. cu. ft.
Detention time ________ Minutes

RECARBONINATION BASIN (2)

Liquid volume ________ Thos. cu. ft.

Detention time ________Minutes

TERTIARY SETTLER (1)
Surface area of settler ________Thos. sq. ft.
Design overflow rate ________gpd/sq. ft.

TERTIARY SETTLER (2)
Surface area of settler ________Thos. sq. ft.
Design overflow rate ________gpd/sq. ft.

GRAVITY THICKENER
Surface arear ________Thos. sq. ft.
Design loading rate ________lbs/sq. ft.
Underflow sludge density ________%

AIR FLOTATION THICKENER
Surface area ________Thos. sq. ft.
Loading rate ________lbs/hr/sq. ft.
Underflow sludge density ________%
Maximum allowable operating time ________Hr/day

ANAEROBIC DIGESTER
Sludge volume ________Thos. cu. ft.
Detention time ________Days
Volatile sludge remaining after digestion ________fraction

AEROBIC DIGESTER
Sludge volume ________Thos. cu. ft.
Detention time ________Days
Volatile sludge remaining after digestion ________fraction

SLUDGE DRYING BEDS
Surface area of beds ________Thos. sq. ft.
Required bed area ________sq. ft./capita

SLUDGE HOLD TANK
Sludge volume ________Thos. cu. ft.
Detention time ________Hours

VACUUM FILTER
Filter area 400 sq. ft.
Loading rate 2 lbs/hr/sq. ft.
Maximum allowable operating time 6 hr/day

CENTRIFUGE
Firm capacity ________gpm
Operating time ________fraction of day

MULTIPLE HEARTH INCINERATION
Capacity ________lbs dry solids/hr
Operating time ________hr/day

FLUIDIZED BED INCINERATION
Capacity ________ lbs dry solids/hr
Operating time ________ hr/day

SLUDGE LAGOON
Sludge volume ________ Thos. cu. ft.
Detention time ________ Days

RECALCINCINATION
Maximum capacity ________ MGD

ALUM FEEDING AND STORAGE
Chemical usage ________ lbs Al/day
Cost of chemical ________ $/lb alum

FERRIC CHLORIDE FEEDING AND STORAGE
Chemical usage 156 lbs Fe/day
Cost of chemical .043 $/lb FeCl3

LIME FEEDING AND STORAGE
Chemical usage 1400 lbs CaO/day
Cost of chemical .0225 $ /lb CaO

POLYMER FEEDING AND STORAGE
Chemical usage ________ lbs polymer/day
Cost of chemical ________ $/lb polymer

CARBON DIOXIDE FEEDING AND STORAGE
Chemical usage ________ lbs/day
Cost of chemical ________ $/lb CO2

SODIUM ALUMINATE FEEDING AND STORAGE
Chemical usage ________ lbs Al/day
Cost of chemical ________ $/lb NaAl

PICKLE LIQUOR FEEDING AND STORAGE
Chemical usage ________ lbs Fe/day
Cost of chemical ________ $/lb FeCl2

SODIUM HYDROXIDE FEEDING AND STORAGE
Chemical usage ________ lbs/day
Cost of chemical ________ $/lb NaOH

```
1         CASE 1 - A 1.5 MGD ACTIVATED SLUDGE PLANT AT MARLBORO, MA
.0175     ELECOS
4.10      DHR
A         TPFRAC
2         ENCTYP
16000.    SPOP
1973.     PYEAR
16000.    SPOP
1975.     PYEAR
A         TRNCST
A         CAP
9.        DIST
99.       END OF SOLID SINK DATA
A         CNSTRC
A         MATRLS
A         ALKIPS
350.      BODIPS
2600.     MLSSAR
A         NH3IAR
A         PINPS
1.5       QAVE
2.4       QPEAK
325.      SSINPS
A         TPDFAP
A         ASD
A         FLOTUD
A         GRAVLD
A         PSETLD
A         VFPSLG
A         VSANRM
A         VSARM
A         HPOST
6.        HPOVE
A         PSHAVE
A         AMRATE
A         AMLIFE
2.5       RAW WASTE PUMPING
A
2.5       PRE TREATMENT
A
3.18      PRIMARY SETTLER
315.
110.      PRIMARY SLUDGE PUMPING
8.
A         TRICKLING FILTER
97.2      AERATION BASIN
17.4
A         DIFFUSED AIR SYSTEM
```

```
120.      MECHANICAL AERAITON
1.86
A         FLOCCULATION - PRIMARY
2.51      SECONDARY SETTLER
358.
2.5       RECIRCULATION PUMPING
A
33.       CHLORINE FEEDING
8.
5.6       CHLORINE BASIN
30.
A         MULTI-MEDIA FILTER
A         RECIRCULATION PUMPING
A         GRAVITY THICKENER
A         AIR FLOTATION THICKENER
A         ANAEROBIC DIGESTER
A         AEROBIC DIGESTER
A         SLUDGE DRYING BEDS
A         SLUDGE HOLDING TANK
400.      VACUUM FILTER
2.
A         CENTRIFUGE
A         MULTIPLE-HEARTH INCINERATION
A         FLUIDIZED BED INCINERATION
A         WASTE STABLILATION POND
A         SLUDGE LAGOON
A         RECARBONATION 1
A         RECARBONATION 2
A         TERTIARY SETTLER 1
A         TERTIARY SETTLER 2
A         ALUM F&S
156.      FECL3 F&S
.027
1400.     LIME F&S
.0225
99.       END OF PROCESS DATA
1         NCYEARS
1.        TPSIZE
.5        GOVFF
2.01      ELIMT
1973.     FYEAR
99.       END OF P EFF DATA
YES       DETERGENT RESTRICTIONS
.02       DIFCCS
16.       DATGLS
.4        ENFCST
.1        PRESPC
.05       PCNTNT
1973.     PYEAR
YES       SUPRESS WARNING MESSAGES
```

APPENDIX B

GENERAL - Case 2 - Clinton, Mass.

DATE 21 MAR 73
YOUR NAME Ed Garrity
TITLE Sewage Plant Operator
PHONE 617 365 6144
Name of treatment plant Clinton Sewage Plant
Street North High St
City Clinton
State & ZIP MA

COMMUNITY

What is the present sewered population served by this plant?
13 000 - 14 000

Do you have quantitative knowledge of the future sewered population? YES ✓ NO___

If the answer to the above question was YES, then please give the future population values and their corresponding years.

SEWERED POP.	YEAR
17 000	1975
25 000	1990

What is the average direct hourly labor rate for all employees? 4 $/Hour

What are the indirect labor costs expressed as a fraction of direct labor costs? ________ (fraction)

What is the average cost of electricity? ______$/KWHr

Do you dispose of sewage sludge on land? YES ✓ NO___

If the answer to above is YES, then please give the capacity and the distance from the plant to the landfill site for each available landfill site.

CAPACITY (tons)	DISTANCE (miles)
infinite	4

What is the average sost of transporting 1 ton of dry sludge 1 mile to a landfill site? __1.50__ $

What phosphorus effluent level would you like to achieve? ________ mg/l

What (if any) is the present legislated limit on phosphorus content in detergents? ________ % Phosphorus

What (if any) are the proposed detergent phosphorus limits and their years of implementation?

% P	YEAR

If there are (or will be) limits on detergent phosphorus, what is the cost of enforcing these limits? ________ $/capita/year

SEWAGE

What is the average flow into your treatment plant? __2__ MGD

What is the peak diurnal flow? __3__ MGD

What is the phosphorus concentration into the primary settler? ________ mg/l

What is the BOD5 concentration into the primary settler? __145__ mg/l

What is the suspended solids concentration into the primary

settler? 70 mg/l

What is the alkalinity concentration into the primary settler? 84 mg CaCO3/l

If your plant has an aeration process (activated sludge or trickling filter):

What is the mixed liquor suspended solids concentration into the aeration process? ________mg/l

What is the NH3 concentration into the aeration process? ________mg/l

What is the total change in BOD5 (i.e., the fraction removed) across the aeration process? ________(fraction removed)

TREATMENT PLANT

The following questions concern the individual treatment processes. If you do not have a particular process in your treatment plant or you do not know a particular value desired, then please leave the answer space blank. If there are multiple pieces of equipment operating in parallel for a particular process their sizes should be summed together for this questionnaire. Note: A number in parantheses following a process name refers to a process operating in series in relation to the other process of the same name.

RAW WASTE PUMPING
Initial firm capacity 6 MGD

PRE TREATMENT
Maximum capacity 5 MGD

FLOCCULATION BASIN BEFORE PRIMARY
Maximum capacity ________MGD

PRIMARY SETTLER
Surface area of the settler 3.926 Thos. sq. ft.
Design overflow rate 636 gpd/sq. ft.
Underflow sludge density ________%
Per cent removal of suspended solids 28 %
Voltatile fraction of primary sludge ________fraction

PRIMARY SLUDGE PUMPING

Initial firm capacity 150 gpm
Operating hours 2 hr/day

TRICKLING FILTER
Media volume 28.3 Thos. cu. ft.
Filter depth 5 feet
Hydraulic loading 24.46 MGD/acre

AERATION BASIN
Liquid volume ________ Thos. cu. ft.
Detention time ________ Hours
Activated sludge density ________ %

DIFFUSED AIR SYSTEM
Initial firm blower capacity ________ Thos. cfm
Diffuser efficiency ________ fraction

MECHANICAL AERATION
Total install capacity ________ Hp
Transfer efficiency ________ lbs O2/hp-hr

SECONDARY SETTLER
Surface area of the settler 3.926 Thos. sq. ft.
Design overflow rate ________ gpd/sq. ft.

RECIRCULATION PUMPING (1)
Maximum capacity 2.45 MGD

CHLORINATION FEEDING SYSTEM
Average chlorine use 0 lbs/day
Chlorine dosage ________ mg/l

CHLORINATION CONTACT BASIN
Liquid volume ________ Thos. cu. ft.
Chlorine contact time ________ minutes

MULTI-MEDIA FILTER
Capacity ________ MGD

RECIRCULATION PUMPING (2)
Maximum capacity ________ MGD

FLOCCULATION BASIN BEFORE TERTIARY
Maximum capacity ________ MGD

RECARBONINATION BASIN (1)
Liquid volume ________ Thos. cu. ft.
Detention time ________ Minutes

RECARBONINATION BASIN (2)
Liquid volume ________ Thos. cu. ft.

Detention time ________Minutes

TERTIARY SETTLER (1)
Surface area of settler ________Thos. sq. ft.
Design overflow rate ________gpd/sq. ft.

TERTIARY SETTLER (2)
Surface area of settler ________Thos. sq. ft.
Design overflow rate ________gpd/sq. ft.

GRAVITY THICKENER
Surface arear ________Thos. sq. ft.
Design loading rate ________lbs/sq. ft.
Underflow sludge density ________%

AIR FLOTATION THICKENER
Surface area ________Thos. sq. ft.
Loading rate ________lbs/hr/sq. ft.
Underflow sludge density ________%
Maximum allowable operating time ________Hr/day

ANAEROBIC DIGESTER
Sludge volume 35.2 Thos. cu. ft.
Detention time 33 Days
Volatile sludge remaining after digestion ________fraction

AEROBIC DIGESTER
Sludge volume ________Thos. cu. ft.
Detention time ________Days
Volatile sludge remaining after digestion ________fraction

SLUDGE DRYING BEDS
Surface area of beds 24 Thos. sq. ft.
Required bed area ________sq. ft./capita

SLUDGE HOLD TANK
Sludge volume 35.2 Thos. cu. ft.
Detention time ________Hours

VACUUM FILTER
Filter area ________sq. ft.
Loading rate ________lbs/hr/sq. ft.
Maximum allowable operating time ________hr/day

CENTRIFUGE
Firm capacity ________gpm
Operating time ________fraction of day

MULTIPLE HEARTH INCINERATION
Capacity ________lbs dry solids/hr
Operating time ________hr/day

FLUIDIZED BED INCINERATION
Capacity ________lbs dry solids/hr
Operating time ________hr/day

SLUDGE LAGOON
Sludge volume ________Thos. cu. ft.
Detention time ________Days

RECALINCINATION
Maximum capacity ________MGD

ALUM FEEDING AND STORAGE
Chemical usage ________lbs Al/day
Cost of chemical ________$/lb alum

FERRIC CHLORIDE FEEDING AND STORAGE
Chemical usage ________lbs Fe/day
Cost of chemical ________$/lb FeCl3

LIME FEEDING AND STORAGE
Chemical usage ________lbs CaO/day
Cost of chemical ________$ /lb CaO

POLYMER FEEDING AND STORAGE
Chemical usage ________lbs polymer/day
Cost of chemical ________$/lb polymer

CARBON DIOXIDE FEEDING AND STORAGE
Chemical usage ________lbs/day
Cost of chemical ________$/lb CO2

SODIUM ALUMINATE FEEDING AND STORAGE
Chemical usage ________lbs Al/day
Cost of chemical ________$/lb NaAl

PICKLE LIQUOR FEEDING AND STORAGE
Chemical usage ________lbs Fe/day
Cost of chemical ________$/lb FeCl2

SODIUM HYDROXIDE FEEDING AND STORAGE
Chemical usage ________lbs/day
Cost of chemical ________$/lb NaOH

```
2         CASE 2 - A 2 MGD TRICKLING FILTER AT CLINTON, MA
.0375     FLECOS
4.        DHR
A         IDFRAC
2         ENCTYP
13500.    SPOPIN
1973.     PYEAR
13500.    SPOP
1975.     PYEAR
1.5       TRNCST
A         CAP
4.        DIST
99.       END OF SOLID SINK DATA
A         CNSTRC
A         MATRLS
84.       ALKIPS
145.      BODIPS
A         MLSSAR
0.        NH3IAR
A         PINPS
2.        QAVE
3.        QPEAK
70.       SSINPS
A         TBODAR
A         ASD
A         FLOTUD
A         GRAVUD
A         PSETUD
A         VFRSLG
A         VSAIRM
A         VSARM
A         HPDET
A         HPDVE
.28       PSEMVE
A         AMRATE
A         AMLIFE
6.        RAW WASTE PUMPING
A
5.        PRE TREATMENT
A
3.926     PRIMARY SETTLER
636.
150.      PRIMARY SLUDGE PUMPING
2.
34.       TRICKLING FILTER
24.5
```

```
A           AERATION BASIN
A           DIFFUSED AIR
A           MECHANICAL AERATION
A           FLOCCULATION - PRIMARY
3.926       SECONDARY SETTLER
636.
2.45        RECIRCULATION PUMPING
A
200.        CHLORINE FEEDING
A
4.2         CHLORINATION BASIN
A
A           MULTI-MEDIA FILTER
A           RECIRCULATION PUMPING
A           GRAVITY THICKENER
A           AIR FLOTATION THICKENER
35.2        ANAEROBIC DIGESTER
33.
A           AEROBIC DIGSETER
24.         SLUDGE DRYING BEDS
A
35.2        SLUDGE HOLDING TANK
A
A           VACUUM FILTER
99.         END OF PROCESS DATA
1           NOYRS
1.          TPSIZE
.5          GOVFF
2.01        FLIMIT
1973.       KYEAR
99.         END OF P EFF DATA
YES         DETERGENT RESTRICTIONS
.02         DIFCOS
16.         DTRGLS
.4          ENECST
.1          PRESPC
.05         PCNTNT
1973.       PYEAR
YES         SUPPRESS WARNING MESSAGES
```

APPENDIX C

Case 3 - Theoretical Plant

```
3          CASE 3 - A 5 MGD TRICKLING FILTER PLANT (HYPOTHETICAL)
A          ELECOS
A          DHR
A          IOFRAC
2          FNCTYP
50000.     SPOPIN
1973.      PYEAR
50000.     SPOP
1977.      PYEAR
A          TRNCST
A          CAP
5.         DIST
99.        END OF SOLID SINK DATA
A          CNSTRC
A          MATRLS
A          ALKIPS
A          BODIPS
A          MLSSAR
A          NH3IAR
A          PINPS
5.         QAVE
9.         QPEAK
A          SSINPS
A          TBODAR
A          ASD
A          FLOTUD
A          GRAVUC
A          PSETUD
A          VFPSLG
A          VSANRM
A          VSARM
A          HPOFT
A          HPOVF
A          PSRMVE
A          AMRATE
A          AMLIFE
9.         RAW WASTE PUMPING
A
9.         PRE TREATMENT
A
7.2        PRIMARY SETTLER
A
70.        PRIMARY SLUDGE PUMPING
A
283.       TRICKLING FILTER
A
```

```
A         AERATION BASIN
A         DIFFUSED AIR
A         MECHANICAL AERATION
A         FLOCCULATION - PRIMARY
7.2       SECONDARY SETTLER
A
7.5       RECIRCULATION PUMPING
A
600.      CHLORINE FEEDING
A
13.       CHLORINATION BASIN
A
A         MULTI-MEDIA FILTER
A         RECIRCULATION PUMPING
.6        GRAVITY THICKENER
A
A         AIR FLOTATION THICKENER
A         ANAEROBIC DIGESTER
A         AEROBIC DIGSETER
A         SLUDGE DRYING BEDS
6.5       SLUDGE HOLDING TANK
A
127.      VACUUM FILTER
A
99.       END OF PROCESS DATA
1         NOYRS
1.        TPSIZE
.5        GOVFF
2.0       ELIMIT
1973.     EYEAR
99.       END OF P FEE DATA
YES       DETERGENT RESTRICTIONS
.02       DIFCCS
16.       DTRGLS
.4        ENECST
.1        PRESPC
.05       PCNTNT
1973.     PYEAR
YES       SUPRESS WARNING MESSAGES
```

APPENDIX D

GENERAL - Case 4 - Brockton, Mass.

DATE 29 MAR 73
YOUR NAME Timothy Murphy
TITLE Plant Supt
PHONE 617 586 6735
Name of treatment plant Brockton
Street Oak Hill Way
City Brockton
State & ZIP MA 02401

COMMUNITY

What is the present sewered population served by this plant?
90 000

Do you have quantitative knowledge of the future sewered population? YES ✓ NO___

If the answer to the above question was YES, then please give the future population values and their corresponding years.

SEWERED POP.	YEAR
100 000	1980

What is the average direct hourly labor rate for all employees? 4 $/Hour

What are the indirect labor costs expressed as a fraction of direct labor costs? ________ (fraction)

What is the average cost of electricity? _______ $/KWHr

Do you dispose of sewage sludge on land? YES ✓ NO___

If the answer to above is YES, then please give the capacity and the distance from the plant to the landfill site for each available landfill site.

CAPACITY (tons)	DISTANCE (miles)
infinite	0

__________ __________
__________ __________
__________ __________
__________ __________
__________ __________
__________ __________
__________ __________
__________ __________
__________ __________
__________ __________

What is the average sost of transporting 1 ton of dry sludge 1 mile to a landfill site? ________$

What phosphorus effluent level would you like to achieve?
__.05__mg/l

What (if any) is the present legislated limit on phosphorus content in detergents? ________% Phosphorus

What (if any) are the proposed detergent phosphorus limits and their years of implementation?

% P	YEAR

If there are (or will be) limits on detergent phosphorus, what is the cost of enforcing these limits?
________$/capita/year

SEWAGE

What is the average flow into your treatment plant?
__12__MGD

What is the peak diurnal flow? __15__MGD

What is the phosphorus concentration into the primary settler? __15__mg/l

What is the BOD5 concentration into the primary settler?
__350__mg/l

What is the suspended solids concentration into the primary

settler? 210 mg/l

What is the alkalinity concentration into the primary settler? 100 mg CaCO3/l

If your plant has an aeration process (activated sludge or trickling filter):

What is the mixed liquor suspended solids concentration into the aeration process? ________mg/l

What is the NH3 concentration into the aeration process? ________mg/l

What is the total change in BOD5 (i.e., the fraction removed) across the aeration process? .85 (fraction removed)

TREATMENT PLANT

The following questions concern the individual treatment processes. If you do not have a particular process in your treatment plant or you do not know a particular value desired, then please leave the answer space blank. If there are multiple pieces of equipment operating in parallel for a particular process their sizes should be summed together for this questionnaire. Note: A number in parantheses following a process name refers to a process operating in series in relation to the other process of the same name.

RAW WASTE PUMPING
Initial firm capacity 24 MGD

PRE TREATMENT
Maximum capacity 30 MGD

FLOCCULATION BASIN BEFORE PRIMARY
Maximum capacity ________MGD

PRIMARY SETTLER
Surface area of the settler 16.2 Thos. sq. ft.
Design overflow rate 750 gpd/sq. ft.
Underflow sludge density 3-4 %
Per cent removal of suspended solids 50 %
Voltatile fraction of primary sludge .75 fraction

PRIMARY SLUDGE PUMPING

Initial firm capacity 160 gpm
Operating hours 24 hr/day

TRICKLING FILTER
Media volume ________ Thos. cu. ft.
Filter depth ________ feet
Hydraulic loading ________ MGD/acre

AERATION BASIN
Liquid volume 454 Thos. cu. ft.
Detention time 6 Hours
Activated sludge density .5 %

DIFFUSED AIR SYSTEM
Initial firm blower capacity ________ Thos. cfm
Diffuser efficiency ________ fraction

MECHANICAL AERATION
Total install capacity 450 Hp
Transfer efficiency 3.07 lbs 02/hp-hr

SECONDARY SETTLER
Surface area of the settler 19 Thos. sq. ft.
Design overflow rate 640 gpd/sq. ft.

RECIRCULATION PUMPING (1)
Maximum capacity 15 MGD

CHLORINATION FEEDING SYSTEM
Average chlorine use 400 lbs/day
Chlorine dosage 7 mg/l

CHLORINATION CONTACT BASIN
Liquid volume 26 Thos. cu. ft.
Chlorine contact time 15 minutes

MULTI-MEDIA FILTER
Capacity ________ MGD

RECIRCULATION PUMPING (2)
Maximum capacity ________ MGD

FLOCCULATION BASIN BEFORE TERTIARY
Maximum capacity ________ MGD

RECARBONINATION BASIN (1)
Liquid volume ________ Thos. cu. ft.
Detention time ________ Minutes

RECARBONINATION BASIN (2)
Liquid volume ________ Thos. cu. ft.

Detention time ________ Minutes

TERTIARY SETTLER (1)

Surface area of settler ________ Thos. sq. ft.
Design overflow rate ________ gpd/sq. ft.

TERTIARY SETTLER (2)

Surface area of settler ________ Thos. sq. ft.
Design overflow rate ________ gpd/sq. ft.

GRAVITY THICKENER

Surface arear ________ Thos. sq. ft.
Design loading rate ________ lbs/sq. ft.
Underflow sludge density ________ %

AIR FLOTATION THICKENER

Surface area 1.03 Thos. sq. ft.
Loading rate .3 lbs/hr/sq. ft.
Underflow sludge density 4 %
Maximum allowable operating time 24 Hr/day

ANAEROBIC DIGESTER

Sludge volume 54 Thos. cu. ft.
Detention time 30 Days
Volatile sludge remaining after digestion .6 fraction

AEROBIC DIGESTER

Sludge volume ________ Thos. cu. ft.
Detention time ________ Days
Volatile sludge remaining after digestion ________ fraction

SLUDGE DRYING BEDS

Surface area of beds ________ Thos. sq. ft.
Required bed area ________ sq. ft./capita

SLUDGE HOLD TANK

Sludge volume 25.2 Thos. cu. ft.
Detention time ________ Hours

VACUUM FILTER

Filter area 600 sq. ft.
Loading rate 1.88 lbs/hr/sq. ft.
Maximum allowable operating time 24 hr/day

CENTRIFUGE

Firm capacity ________ gpm
Operating time ________ fraction of day

MULTIPLE HEARTH INCINERATION

Capacity ________ lbs dry solids/hr
Operating time ________ hr/day

FLUIDIZED BED INCINERATION
Capacity ________lbs dry solids/hr
Operating time ________hr/day

SLUDGE LAGOON
Sludge volume ________Thos. cu. ft.
Detention time ________Days

RECALINCINATION
Maximum capacity ________MGD

ALUM FEEDING AND STORAGE
Chemical usage ________lbs Al/day
Cost of chemical ________$/lb alum

FERRIC CHLORIDE FEEDING AND STORAGE
Chemical usage 204 lbs Fe/day
Cost of chemical .03 $/lb FeCl3

LIME FEEDING AND STORAGE
Chemical usage 250 lbs CaO/day
Cost of chemical .022 $ /lb CaO

POLYMER FEEDING AND STORAGE
Chemical usage ________lbs polymer/day
Cost of chemical ________$/lb polymer

CARBON DIOXIDE FEEDING AND STORAGE
Chemical usage ________lbs/day
Cost of chemical ________$/lb CO2

SODIUM ALUMINATE FEEDING AND STORAGE
Chemical usage ________lbs Al/day
Cost of chemical ________$/lb NaAl

PICKLE LIQUOR FEEDING AND STORAGE
Chemical usage ________lbs Fe/day
Cost of chemical ________$/lb FeCl2

SODIUM HYDROXIDE FEEDING AND STORAGE
Chemical usage ________lbs/day
Cost of chemical ________$/lb NaOH

```
 4         CASE 4 - A 12 MGD ACTIVATED SLUDGE PLANT AT BROCKTON ,MA
 .C175     ELECCS
 4.        DHR
 A         IDFRAC
 2         ENGTYP
 9C0C0.    SPOP
 1973.     PYEAR
 9C000.    SPOP
 1975.     PYEAR
 0.        TRNCST
 Δ         CAP
 0.        DIST
 99.       END OF SOLID SINK DATA
 Δ         CNSTRC
 Δ         MATRLS
 1C0.      ALKIPS
 350.      BODIPS
 2500.     MLSSAR
 A         NH3IAR
 15.       PINPS
 12.       QAVE
 15.       QPEAK
 200.      SSINPS
 .85       TBDEAR
 .C05      ASD
 .04       FLOTUC
 Δ         GRAVUC
 .035      PSETLC
 .75       VERSLC
 .60       VSANRM
 Δ         VSARM
 24.       HPDET
 24.       HPDVE
 .5        PSRMVE
 Δ         AMRATE
 A         AMLIFE
 24.       RAW WASTE PUMPING
 Δ
 30.       PRE TREATMENT
 Δ
 16.2      PRIMARY SETTLER
 750.
 160.      PRIMARY SLUDGE PUMPING
 24.
 Δ         TRICKLING FILTER
 454.      AERATION BASIN
 6.
 Δ         DIFFUSED AIR SYSTEM
 450.      MECHANICAL AERATION
 3.07
```

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A         FLOCCULATION - PRIMARY
19.       SECONDARY SETTLER
640.
15.       RECIRCULATION PUMPING
A
400.      CHLORINE FEEDING
7.
26.       CHLORINE BASIN
15.
A         MULTI - MEDIA FILTER
A         RECIRCULATION PUMPING
A         GRAVITY THICKENER
1.03      FLOTATION THICKNER
.3
54.       ANAEROBIC DIGESTER
30.
A         AEROBIC DIGESTER
A         SLUDGE DRYING BEDS
25.2      SLUDGE HOLDING TANK
A
600.      VACUUM FILTER
1.88
A         CENTRIFUGE
A         MULTIPLE HEARTH INCINERATION
A         FLUIDIZED BED INCINERATION
A         WASTE STABLIZATION POND
A         SLUDGE LAGOON
A         RECARBONATION 1
A         RECARBONATION 2
A         TERTIARY SETTLER 1
A         TERTIARY SETTLER 2
A         ALUM FEEDING & STORAGE
204.      FERRIC CHLORIDE FEEDING & STORAGE
.03
250.      LIME FEEDING & STORAGE
.022
99.       END OF PROCESS DATA
3         NOYEARS
1.        TPSIZE
.5        GOVFF
2.01      FLIMT
1973.     FYEAR
99.       END OF P EFF DATA
YES       DETERGENT RESTRICTIONS
.02       DIFCOS
27.       DTRGLS
.4        ENFCST
.1        PHOSPC
.05       PCNTNT
1973.     PYEAR
YES       SUPRESS WARNING MESSAGES
```

APPENDIX E

GENERAL - Case 5 - Providence, R.I.

DATE 28 MAR 73
YOUR NAME Tom Boutier
TITLE Asst. Supt.
PHONE 401 461 1865
Name of treatment plant Providence
Street 2 Ernest St.
City Providence
State & ZIP Rhode Island

COMMUNITY

What is the present sewered population served by this plant?
225 000

Do you have quantitative knowledge of the future sewered population? YES___ NO_✓_

If the answer to the above question was YES, then please give the future population values and their corresponding years.

SEWERED POP.	YEAR

What is the average direct hourly labor rate for all employees? 3.10 $/Hour

What are the indirect labor costs expressed as a fraction of direct labor costs? ________ (fraction)

What is the average cost of electricity? _______$/KWHr

Do you dispose of sewage sludge on land? YES_✓_ NO___

If the answer to above is YES, then please give the capacity and the distance from the plant to the landfill site for each available landfill site.

CAPACITY (tons)	DISTANCE (miles)
infinite	2

________ ________
________ ________
________ ________
________ ________
________ ________
________ ________
________ ________
________ ________
________ ________
________ ________

What is the average sost of transporting 1 ton of dry sludge 1 mile to a landfill site? ________$

What phosphorus effluent level would you like to achieve? ________mg/l

What (if any) is the present legislated limit on phosphorus content in detergents? ________% Phosphorus

What (if any) are the proposed detergent phosphorus limits and their years of implementation?

% P	YEAR

If there are (or will be) limits on detergent phosphorus, what is the cost of enforcing these limits? ________$/capita/year

SEWAGE

What is the average flow into your treatment plant? 50 MGD 200 MGD rainy day - combined sewers

What is the peak diurnal flow? 80 MGD dry day

What is the phosphorus concentration into the primary settler? ________mg/l

What is the BOD5 concentration into the primary settler? 79 mg/l

What is the suspended solids concentration into the primary

settler? __95__ mg/l

What is the alkalinity concentration into the primary settler? ________ mg CaCO3/l

If your plant has an aeration process (activated sludge or trickling filter):

What is the mixed liquor suspended solids concentration into the aeration process? __3500__ mg/l

What is the NH3 concentration into the aeration process? ________ mg/l

What is the total change in BOD5 (i.e., the fraction removed) across the aeration process? __.75__ (fraction removed)

TREATMENT PLANT

The following questions concern the individual treatment processes. If you do not have a particular process in your treatment plant or you do not know a particular value desired, then please leave the answer space blank. If there are multiple pieces of equipment operating in parallel for a particular process their sizes should be summed together for this questionnaire. Note: A number in parantheses following a process name refers to a process operating in series in relation to the other process of the same name.

RAW WASTE PUMPING
Initial firm capacity __200__ MGD

PRE TREATMENT
Maximum capacity __100__ MGD

FLOCCULATION BASIN BEFORE PRIMARY
Maximum capacity ________ MGD

PRIMARY SETTLER
Surface area of the settler __38.68__ Thos. sq. ft.
Design overflow rate __1650__ gpd/sq. ft.
Underflow sludge density __5-6__ %
Per cent removal of suspended solids __30__ %
Voltatile fraction of primary sludge ________ fraction

PRIMARY SLUDGE PUMPING

Initial firm capacity 5000 gpm
Operating hours 24 hr/day

TRICKLING FILTER

Media volume ________ Thos. cu. ft.
Filter depth ________ feet
Hydraulic loading ________ MGD/acre

AERATION BASIN

Liquid volume 1470 Thos. cu. ft.
Detention time 4 Hours
Activated sludge density 1 %

DIFFUSED AIR SYSTEM

Initial firm blower capacity 62.5 Thos. cfm
Diffuser efficiency ________ fraction

MECHANICAL AERATION

Total install capacity ________ Hp
Transfer efficiency ________ lbs O2/hp-hr

SECONDARY SETTLER

Surface area of the settler 73.5 Thos. sq. ft.
Design overflow rate 800 gpd/sq. ft.

RECIRCULATION PUMPING (1)

Maximum capacity 28.5 MGD

CHLORINATION FEEDING SYSTEM

Average chlorine use 6000 lbs/day
Chlorine dosage 10 t 12 mg/l

CHLORINATION CONTACT BASIN

Liquid volume 71.93 Thos. cu. ft.
Chlorine contact time 20 minutes

MULTI-MEDIA FILTER

Capacity ________ MGD

RECIRCULATION PUMPING (2)

Maximum capacity ________ MGD

FLOCCULATION BASIN BEFORE TERTIARY

Maximum capacity ________ MGD

RECARBONINATION BASIN (1)

Liquid volume ________ Thos. cu. ft.
Detention time ________ Minutes

RECARBONINATION BASIN (2)

Liquid volume ________ Thos. cu. ft.

Detention time ________Minutes

TERTIARY SETTLER (1)

Surface area of settler ________Thos. sq. ft.
Design overflow rate ________gpd/sq. ft.

TERTIARY SETTLER (2)

Surface area of settler ________Thos. sq. ft.
Design overflow rate ________gpd/sq. ft.

GRAVITY THICKENER

Surface arear 6.36 Thos. sq. ft.
Design loading rate ________lbs/sq. ft./hr.
Underflow sludge density 8-10 %

AIR FLOTATION THICKENER

Surface area ________Thos. sq. ft.
Loading rate ________lbs/hr/sq. ft.
Underflow sludge density ________%
Maximum allowable operating time ________Hr/day

ANAEROBIC DIGESTER

Sludge volume ________Thos. cu. ft.
Detention time ________Days
Volatile sludge remaining after digestion ________fraction

AEROBIC DIGESTER

Sludge volume ________Thos. cu. ft.
Detention time ________Days
Volatile sludge remaining after digestion ________fraction

SLUDGE DRYING BEDS

Surface area of beds ________Thos. sq. ft.
Required bed area ________sq. ft./capita

SLUDGE HOLD TANK

Sludge volume ________Thos. cu. ft.
Detention time ________Hours

VACUUM FILTER

Filter area 1440 sq. ft.
Loading rate 6 lbs/hr/sq. ft.
Maximum allowable operating time 24 hr/day

CENTRIFUGE

Firm capacity ________gpm
Operating time ________fraction of day

MULTIPLE HEARTH INCINERATION

Capacity 8000 lbs dry solids/hr
Operating time 24 hr/day

FLUIDIZED BED INCINERATION

Capacity ________lbs dry solids/hr

Operating time ________hr/day

SLUDGE LAGOON

Sludge volume ________Thos. cu. ft.

Detention time ________Days

RECALINCINATION

Maximum capacity ________MGD

ALUM FEEDING AND STORAGE

Chemical usage ________lbs Al/day

Cost of chemical ________$/lb alum

FERRIC CHLORIDE FEEDING AND STORAGE

Chemical usage 250 lbs Fe/day

Cost of chemical .02 $/lb $FeCl_3$

LIME FEEDING AND STORAGE

Chemical usage 8087 lbs CaO/day

Cost of chemical .0075 $ /lb CaO

POLYMER FEEDING AND STORAGE

Chemical usage ________lbs polymer/day

Cost of chemical ________$/lb polymer

CARBON DIOXIDE FEEDING AND STORAGE

Chemical usage ________lbs/day

Cost of chemical ________$/lb CO_2

SODIUM ALUMINATE FEEDING AND STORAGE

Chemical usage ________lbs Al/day

Cost of chemical ________$/lb NaAl

PICKLE LIQUOR FEEDING AND STORAGE

Chemical usage ________lbs Fe/day

Cost of chemical ________$/lb $FeCl_2$

SODIUM HYDROXIDE FEEDING AND STORAGE

Chemical usage ________lbs/day

Cost of chemical ________$/lb NaOH

```
5         CASE 5 - A 50 MGD ACTIVATED SLUDGE PLANT AT PROVIDENCE, RI
.0175     ELECCS
3.10      DHR
A         IDFRAC
2         ENGTYP
225000.   SPOP
1973.     PYEAR
225000.   SPOP
1980.     PYEAR
A         TRNCST
A         CAP
2.        DIST
99.       END OF SOLID SINK DATA
A         CNSTRC
A         MATRLS
A         ALKIPS
79.       BODIPS
3500.     MLSSAR
A         NH3IAR
A         PINPS
50.       QAVE
80.       QPEAK
95.       SSINPS
.75       TEMPAR
.01       ASD
A         FLOTUD
.10       GRAVUD
.06       PSETUD
A         VFPSLG
A         VSANRM
A         VSARM
24.       HPDFT
24.       HPDVF
.3        PSRMVF
A         AMRATE
A         AMLIFE
200.      RAW WASTE PUMPING
A
100.      PRE TREATMENT
A
38.88     PRIMARY SETTLER
1650.
5000.     PRIMARY SLUDGE PUMPING
24.
A         TRICKLING FILTER
1470.     AERATION BASIN
4.
62.5      DIFFUSED AIR SYSTEM
A
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A         MECHANICAL AERATION
A         FLOCCULATION - PRIMARY
73.5      SECONDARY SETTLER
800.
28.5      RECIRCULATION PUMPING
A
6000.     CHLORINE FEEDING
11.
72.       CHLORINE BASIN
20.
A         MULTI-MEDIA FILTER
A         RECIRCULATION PUMPING
6.36      GRAVITY THICKENER
A
A         AIR FLOTATION THICKENER
A         ANAEROBIC DIGESTER
A         AEROBIC DIGESTER
A         SLUDGE DRYING BEDS
A         SLUDGE HOLDING TANK
1440.     VACUUM FILTER
6.
A         CENTRIFUGE
8000.     MULTIPLE-HEARTH INCINERATOR
24.
A         FLUIDIZED BED INCINERATOR
A         WASTE STABLIZATION POND
A         SLUDGE LAGOON
A         RECARBONATION 1
A         RECARBONATION 2
A         TERTIARY SETTLER 1
A         TERTIARY SETTLER 2
A         ALUM FES
250.      FECL3 FES
.02
8007.     LIME FES
.0075
99.       END OF PROCESS DATA
1         NOYEARS
1.        TPSIZE
.5        GOVER
2.01      FLIMT
1973.     FYEAR
99.       END OF PLEFF DATA
YES       ENDPOINT RESTRICTIONS
.02       DIRCOS
16.       DTRCLS
.4        ENRCST
.1        PHOSPC
.05       PCNTNT
1973.     PYEAR
YES       SUPRESS WARNING MESSAGES
```